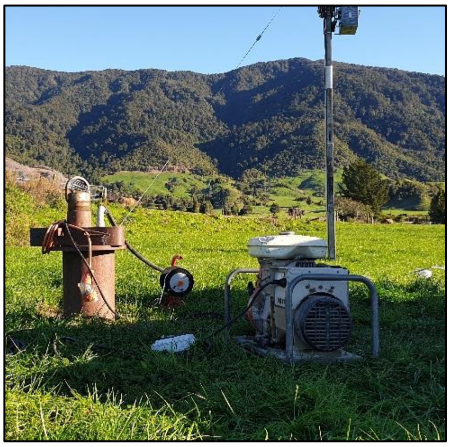
Technical Report

Aorere/West Coast Groundwater Quality Survey 2021



Technical Report

AORERE/WEST COAST GROUNDWATER QUALITY SURVEY 2021

June 2022

A technical report presenting results of the Tasman District Council's groundwater quality synoptic survey undertaken in the Aorere/West Coast Water Management Zone. The report draws on various monitoring data collected by Tasman District Council, including that collected for the Institute of Environmental Science and Research as part of the national survey of pesticides, glyphosate and emerging organic contaminants.

Prepared By:

Melanie Westley[1]

Reviewed By:

Joseph Thomas[1]

Tasman District Council File Ref:

[1] Tasman District Council
189 Queen Street
Private Bag 4
RICHMOND

EXECUTIVE SUMMARY

In April 2021 a water quality survey was undertaken in the Aorere/West Coast Water Management Zone. 28 groundwater sites and 21 surface water sites spread across the various river catchments in the Aorere/West Coast. This is the first time that a wide-scale water quality sampling survey has been undertaken in the Aorere/West Coast. There have been smaller synoptic surveys (i.e. lots of sites sampled over a short time) for localised parts of this area for groundwater quality in the coastal settlements of Parapara, Pākawau and Totara Avenue in 2004/05, 2006/07, 2014/15. There is one long term groundwater monitoring bore in the Aorere/West Coast Water Management Zone (GW 23759 – Collingwood), which has been sampled every three months since December 2015.

Overall, the 2021 sampling has shown relatively good water quality in the Aorere/West Coast Water Management Zone. However, localised contamination of *Escherichia coli* (*E.coli*) was common in shallow groundwater sites, both for the inland and coastal sites. Groundwater abstracted from deeper in the aquifer (bores deeper than 10 m below ground level) did not have detections of *E.coli* at the time of sampling.

The Aorere River discharges into Golden Bay through the swampy Ruataniwha Inlet. Groundwater (both shallow and deep) in this area has low pH, low dissolved oxygen and elevated iron and manganese concentrations, indicating reducing conditions could be present in this localised area. Surface water in this area is less impacted by the swampy conditions, with higher pH, slight elevation in iron and manganese detected but at very low concentrations. Groundwater in this area was higher in nitrates compared with surface water, however all nitrates were below the Drinking Water Standards for New Zealand 2005 (Revised 2018) (DWSNZ) (2018) maximum acceptable value (MAV).

Inland, pH remains low in groundwater, though iron and manganese concentrations were lower than groundwater in the Aorere River coastal discharge area. This is similar with surface water, though the pH was slightly higher than groundwater. Limestone intrusions in the Haupiri Range caused localised higher pH along the eastern tributaries for surface water. Groundwater inland was generally higher in nitrates (most below 50% of MAV) compared with river sites (all below 10% of MAV). Nitrates in inland spring sites were slightly worse (between 10% and 50% of MAV). All nitrates however, were below the MAV.

Coastally, groundwater sites had higher pH than inland sites. Limestone intrusions along the Burnett and western Wakamarama Ranges cause localised higher pH in both groundwater and surface water. Rivers had slightly higher pH compared with groundwater sites. Iron and manganese were mostly below the limit of detection. All nitrates were mostly below 10% of MAV.

The results of the water quality survey including groundwater and surface water hydrological investigations will be incorporated into an Aorere/West Coast Freshwater Management Unit Water Resources Report that will inform the development of a water quality and quantity management plan.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

Council	Tasman District Council
DWSNZ	Drinking Water Standards for New Zealand 2005 (Revised 2019)
E.coli	*Escherichia coli* (a faecal indicator bacteria)
EOC	Emerging Organic Contaminant
ESR	Environmental Science and Research Ltd
FMU	Freshwater Management Unit
GV	Guideline Value
MAV	Maximum Acceptable Value
NPSFM	National Policy Statement for Freshwater Management 2014 (Revised 2020)
SoE	State of the Environment

STATEMENT OF DATA VERIFICATION AND LIABILITY

Tasman District Council recognises the importance of good quality data. This assessment of groundwater quality across the Aorere/West Coast Water Management Zone provides interpretation of results from the Council's groundwater quality monitoring programme and other relevant data available at the time of producing the report. Data collection and management systems follow systematic quality control procedures. International Accreditation New Zealand (IANZ) laboratories carried out sample analysis excluding field analysis.

While every attempt has been made to ensure the accuracy of the data and information presented, Tasman District Council does not accept any liability for the accuracy of the information. It is the responsibility of the user to ensure the appropriate use of any data or information from the text, tables or figures. Not all available data or information is presented in the report. Only information considered reliable, of good quality and of most importance to the readers has been included. All tables and figures have been created by the author unless otherwise stated.

1 INTRODUCTION

1.1 Background

The Aorere/West Coast Water Management Zone is one of the Freshwater Management Units (FMU) for the Tasman District. The Aorere/West Coast Water Management Zone is located in the north-west of the South Island, on the western side of Golden Bay (see Figure 1) and is made of several river catchments. It extends from Parapara Inlet to Farewell Spit in the east and along the Tasman Bay coastline from Cape Farewell to Kahurangi Point in the west. The Aorere River is the largest river in the Aorere/West Coast Water Management Zone. It originates in Kahurangi National Park, with the floodplains forming the Aorere valley. The eastern mountain range (Haupiri) separates the Aorere/West Coast Water Management Zone from the rest of Golden Bay. The Wakamarama Range separates the Aorere valley from the west coast, with the Burnett Range separating the Whanganui Inlet from the eastern coastal settlements.

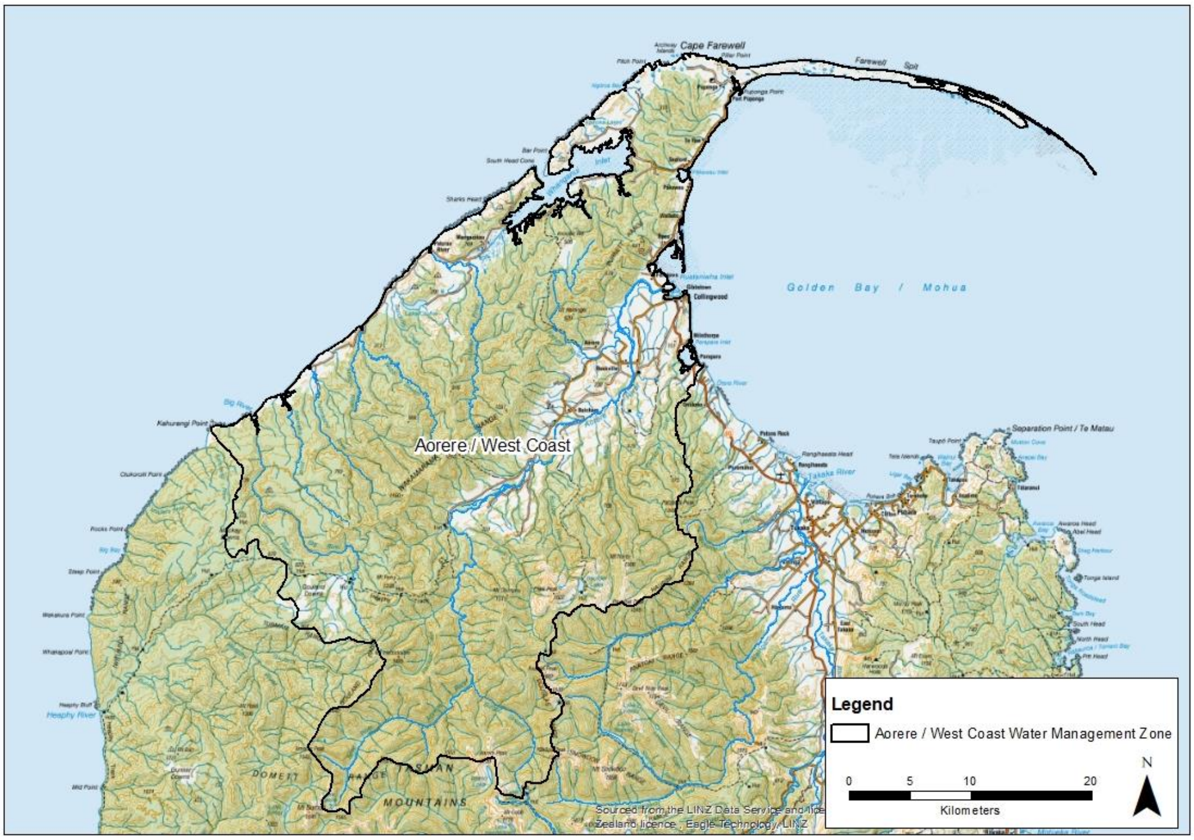


Figure 1: Aorere / West Coast Water Management Zone

The majority of the Aorere/West Coast Water Management Zone is in native forest and conservation land. Primary human land use is dairy farming, particularly in the Aorere valley. The coastal settlements are mostly a mixture of farming, permanent residents, tourism related businesses and holiday homes. The population across the whole of the Aorere/West Coast Water Management Zone was approximately 1,300 people in 2021 (Tasman District Council, 2021a). The largest settlement is Collingwood, with approximately 270 people in 2021 (Tasman District Council, 2021a). Properties in Collingwood are connected to Tasman District Council (Council) water supply (groundwater piped from a well field in the lower Aorere valley) and a wastewater treatment plant for the township located just west of the main township. Outside of Collingwood, properties source water from bores/wells, rainwater collection or surface water abstraction. They also rely on private wastewater disposal systems (such as septic tanks).

Groundwater is found beneath the ground surface. When it rains, some of the rainwater soaks into the soil and travels downwards into the ground. It fills cracks in rocks and pore spaces between grains of sand and gravel until the ground is saturated, creating an underground body of water called an aquifer. Rivers and streams can also gain or lose water to the underlying aquifers depending on the connectivity to the groundwater level relative to river level.

Current knowledge of groundwater resources in the Aorere/West Coast Water Management Zone is limited. The Aorere/West Coast experiences high annual rainfall (> 2,000 mm per year) so groundwater demand is limited. The main aquifer is in the Aorere valley river alluvial terraces. It is unconfined/semiconfined (leaky), and generally flows to the northeast. Recent drilling and testing data show water bearing gravels in this area between 6 – 20 m deep. The Aorere River provides considerable recharge. Away from the river, the aquifer is recharged from rainfall and localised rivers in the side contributing valleys (such as the Kaituna and Slate, among other smaller rivers and streams). Groundwater exits the aquifer system by subsurface flow into Golden Bay and springs in the lower Aorere valley.

In the eastern coastal settlements (from Ruataniwha Inlet to Farewell Spit), the majority of bores/wells source from shallow unconfined aquifers in localised river outwash alluvial and colluvial gravels and coastal sand/gravel deposits. Shallow aquifers in these areas are recharged from the local rivers/streams with some going dry in their lower coastal reaches in summer. The local aquifers also are recharged from rainfall and overland infiltration. Some of the bores north of Pākawau indicate deeper alluvial outwash gravel (> 20 m) and water at these depths are mineralised (with high iron and manganese content).

For private household bores/wells (where the water supply is used only by the people on that property) there is no requirement for the property owner to regularly test the water quality. Most of these household water supplies are either ‘pile driven’ bores or dug wells and are shallow (4 – 8 m deep). Because they take water close to the ground surface, wells and driven bores are considered insecure and it is common for them to often breach the Drinking Water Standards from various contamination sources.

Councils have responsibilities under the Health Act 1956, Section 69U duty to take reasonable steps to contribute to the protection of the source of drinking water. By assessing the water quality and bore details of private bores and wells in Aorere/West Coast Water Management Zone, it provides a better understanding of the risks to groundwater from these bores/wells and also the Council supply bore that abstracts from the same aquifer. In the case of Council water supply bore, Council has a duty to monitor its source water for the Collingwood water supply and within the distribution network.

1.2 Water Quality Survey

In April 2021, a water quality survey was undertaken in the Aorere/West Coast Water Management Zone. The aim was to improve understanding of the groundwater quality and recharge waters in the area. This is the first wide-scale water quality survey to be undertaken in the area. 28 groundwater, 16 river and 5 spring sites were selected. These sites are distributed throughout the Aorere/West Coast Water Management Zone to ensure a range of coastal and inland locations. Figure 2 details the location of the sampling sites.

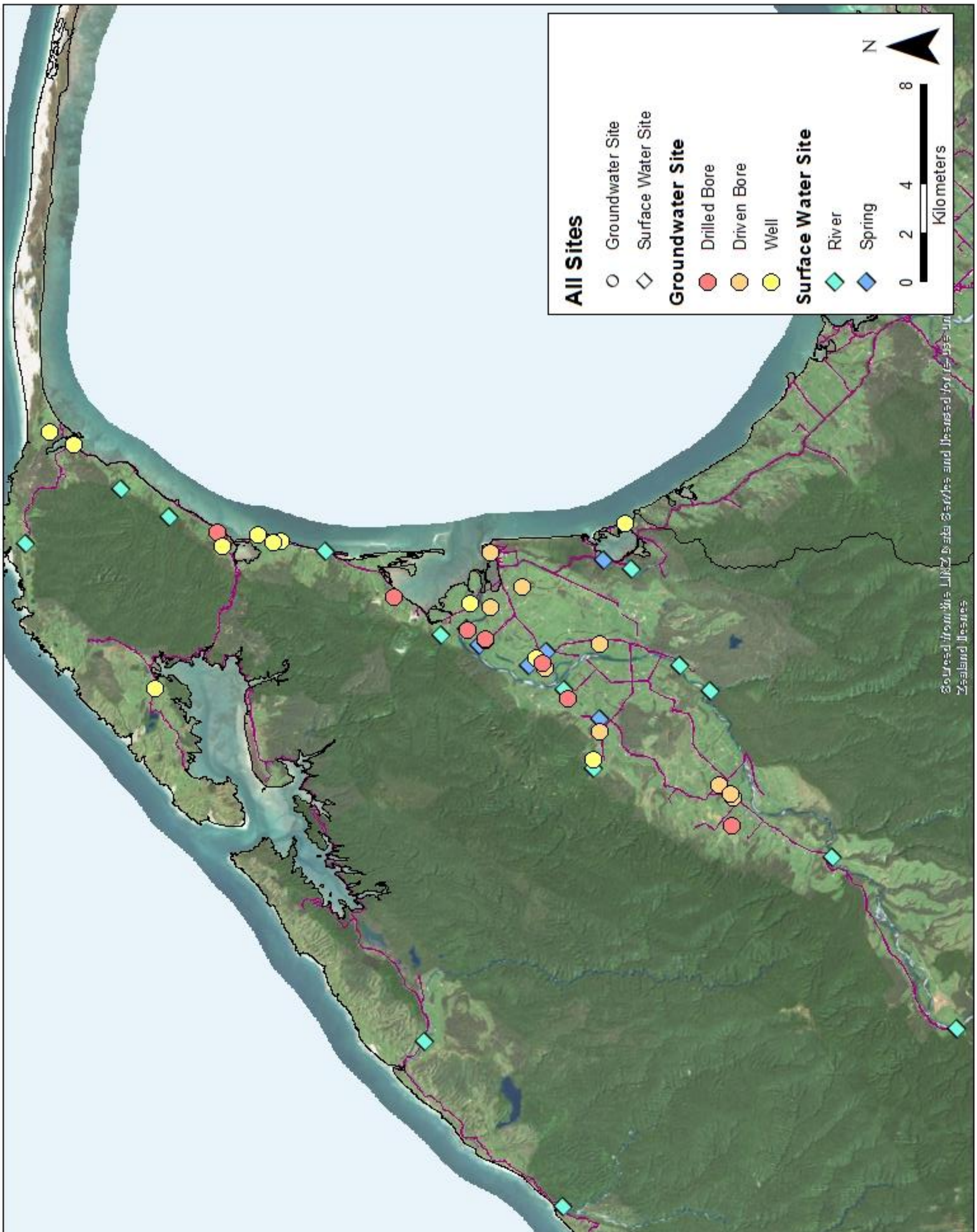


Figure 2: Location of all bores, wells, rivers and spring sites sampled in the 2021 Aorere/West Coast water quality survey.

There were 21 water quality sites located near the coast (8 river sites, 1 spring site, 10 shallow groundwater sites, 2 deep groundwater sites). There were 28 water quality sites located inland (8 river sites, 4 spring sites, 11 shallow groundwater sites, 5 deep groundwater sites).

The groundwater sites include bores and wells which abstract from a range of shallow and deeper groundwater. Of the 28 groundwater sites, 21 were wells or driven bores which access shallow groundwater (generally 4 – 8 m deep). 7 were drilled bores which access deeper groundwater (the deepest bore sampled accessed groundwater from a depth of 135 m below ground level).

2. GROUNDWATER QUALITY

2.1 Groundwater Chemistry

Various chemical parameters were tested for, see Appendix I and II for the full suite of parameters tested for and the sampling methodology respectively. The results were compared against the Drinking Water Standards for New Zealand 2005 (Revised 2018) (DWSNZ) (2018). The DWSNZ has levels for substances of human health significance and aesthetic substances (can affect taste and odour but not human safety). Health significant substances have a maximum acceptable value (MAV), and aesthetic substances have a guideline value (GV). Please refer to Appendix III to see the distribution of selected chemical parameters across the Aorere/West Coast Water Management Zone and Appendix IV to see a breakdown of the parameters in relation to the site location.

The sampling found that *Escherichia coli* (*E.coli*) was the most common DWSNZ parameter to exceed the maximum acceptable value for health significance. The majority of shallow sites (wells or driven bores), regardless of their location (coastal or inland), exceeded the MAV for *E.coli*. The exceedances do appear to be localised, with contamination thought to be occurring due to inappropriate bore/well siting where the bore/well was located in close proximity with activities involving faecal matter (e.g. runoff from milking sheds, see Figure 3) or poor bore/well head protection (see Figure 4).

Figure 3: Bore located in low lying area. Runoff from the milking shed is likely to soak into the ground near the bore.

Figure 4: Well located in paddock without an adequate well head protection. Contamination can easily enter into the groundwater from the well.

Wells and driven bores take shallow groundwater close to the ground surface above it and it is common for these to often breach the Drinking Water Standards. Contamination can include seepage from stagnant water near the bore/well, localised seepage along the edges of the bore/well, animal faecal contamination, septic tank seepage and runoff/seepage following rainfall into the bore/well.

Drilled bores access groundwater from deeper under the ground. None of the deep sites (drilled bores) exceeded the MAV for *E.coli*. All of the deep bores had good bore head protection and were appropriately sited away from potential contamination sources. Drilled bores can also access semi-confined and confined aquifers, which generally have better water quality as there is a confining layer which prevents contamination from seeping from the ground surface. However, semi-confined and confined groundwater are still susceptible to contamination in areas which recharge those aquifers. The deeper the groundwater is taken from the aquifer, the more natural filtration the water experiences as it seeps from the ground surface.

Aside from *E.coli*, the only other exceedance of a DWSNZ health significant parameter (out of the parameters that were tested, see Appendix I) was manganese. The manganese exceedance was from a drilled deep bore (abstracts groundwater from 20 m below the ground) and is located on the coast. The borelog supplied by CW Drilling mentions that vegetated matter was present between 2.70 m and 14.60 m during the drilling process. There is a possibility that the manganese could have originated from this localised buried vegetated matter. This bore has been used in the past for quarrying related purposes. Since December 2020, the bore is no longer used by the quarry. The rest of the bores sampled in this survey had manganese below 50% of the MAV, with the majority below 10% of the MAV and/or below the limit of detection.

As the Aorere River discharges into Golden Bay through the Ruatahiwha Inlet, the ground becomes swampy. Groundwater in this area has higher iron and manganese compared with other coastal and inland sites. Low pH, low dissolved oxygen and low hardness suggests that reducing conditions exist in the groundwater in this area.

Nitrate-N concentrations across the Aorere/West Coast Water Management Zone was below the DWSNZ MAV (see Table 1 for breakdown of nitrate-N by location and Appendix III for the distribution of selected chemical parameters, including nitrate-N). Four groundwater sites were above half of the MAV (above 5.6 g/m^3-N). Reducing conditions often result in low nitrates. Near the Ruataniwha Inlet, where reducing conditions are likely to be present, the nitrate-N concentrations were low.

Table 1: Nitrate-N concentrations in groundwater

Nitrate-N (g/m^3-N)	Shallow Inland Sites	Shallow Coastal Sites	Deep Sites (> 10 m)
Minimum	< 0.002	0.052	< 0.002
Average	2.76	2.22	0.59
Maximum	8.0	8.1	1.49

Inland and coastal groundwater chemistry is dependent on local geology (refer to Appendix V). Limestone intrusions along the Burnett, western Haupiri and western Wakamarama Ranges increase the pH (increased alkalinity), whereas coal seams through the Pākawau Group and Brunner Coal Measures lower the pH (increased acidity).

2.2 Comparison to Previous Synoptic Surveys and State of the Environment Monitoring

Three of the bores/wells tested in 2021 were the same sites sampled in previous synoptic surveys (in 2004/05, 2006/07, 2014/15). These previous synoptic surveys were focused on the eastern coastal settlements of Parapara, Pākawau and Totara Avenue. The Council also has one State of the Environment (SoE) monitoring bore in the Aorere/West Coast Water Management Zone (GW 23759 – Collingwood) which has been sampled four times per year since December 2015.

The parameters which can be compared between previous surveys and SoE monitoring bores are conductivity, iron, nitrate-N, pH and water temperature. Data from previous synoptic surveys and SoE monitoring bores can be seen in the following pages. Please refer to Appendix VI for an explanation of the general trends.

Care is required in interpreting the results. The long-term monitoring bore (GW 23759 – Collingwood) is sampled every three months, which provides adequate data to analyse trends. However, the private bores/wells which have been tested in the past have only been sampled four times since surveying began. It is difficult to establish any definitive trends from four data points, especially as the historic synoptic surveys were undertaken during the summer months. Groundwater can vary seasonally due to a range of factors including changes in rainfall patterns (intensity and volume), river recharge and land use practices throughout the year. This means the results from the synoptic surveys could also be a reflection of the timing of the sample was taken in the year and not an overall groundwater quality trend.

Conductivity (µS/cm)

Figure 5: Measured conductivity concentrations over time for the Aorere/West Coast.

Escherichia coli **(MPN/100mL)**

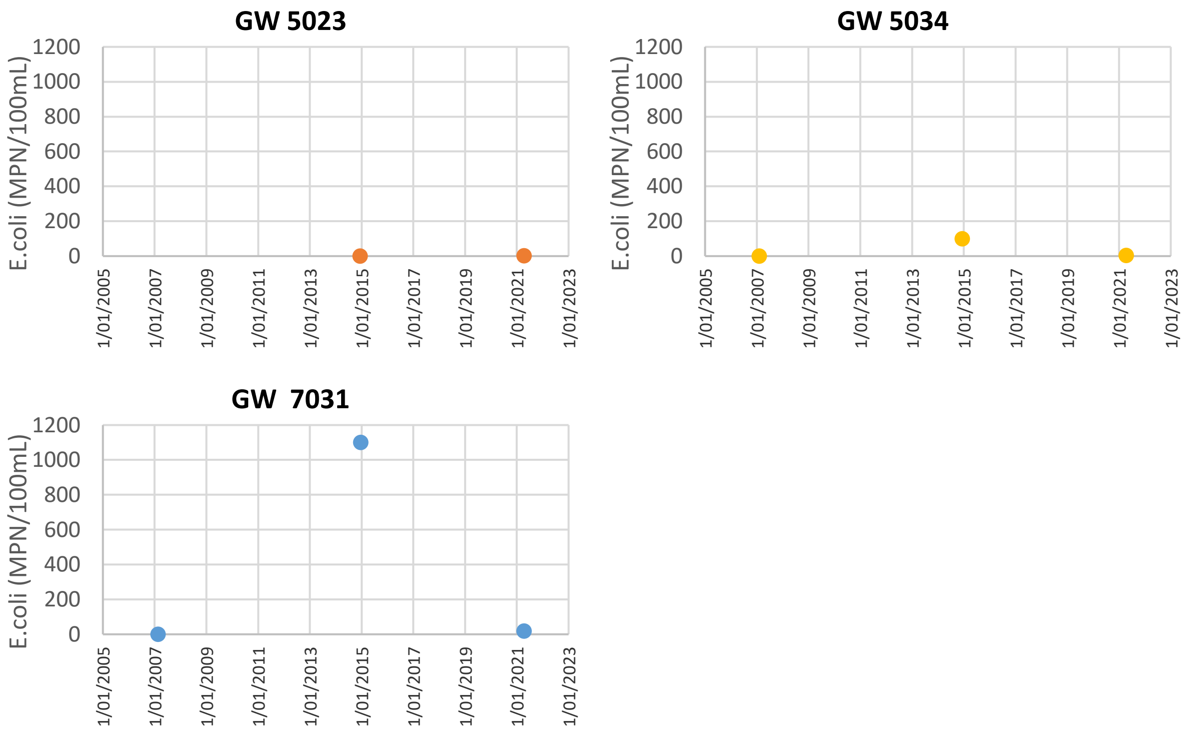


Figure 6: Measured E.coli data over time for the Aorere/West Coast.

Iron (g/m³)

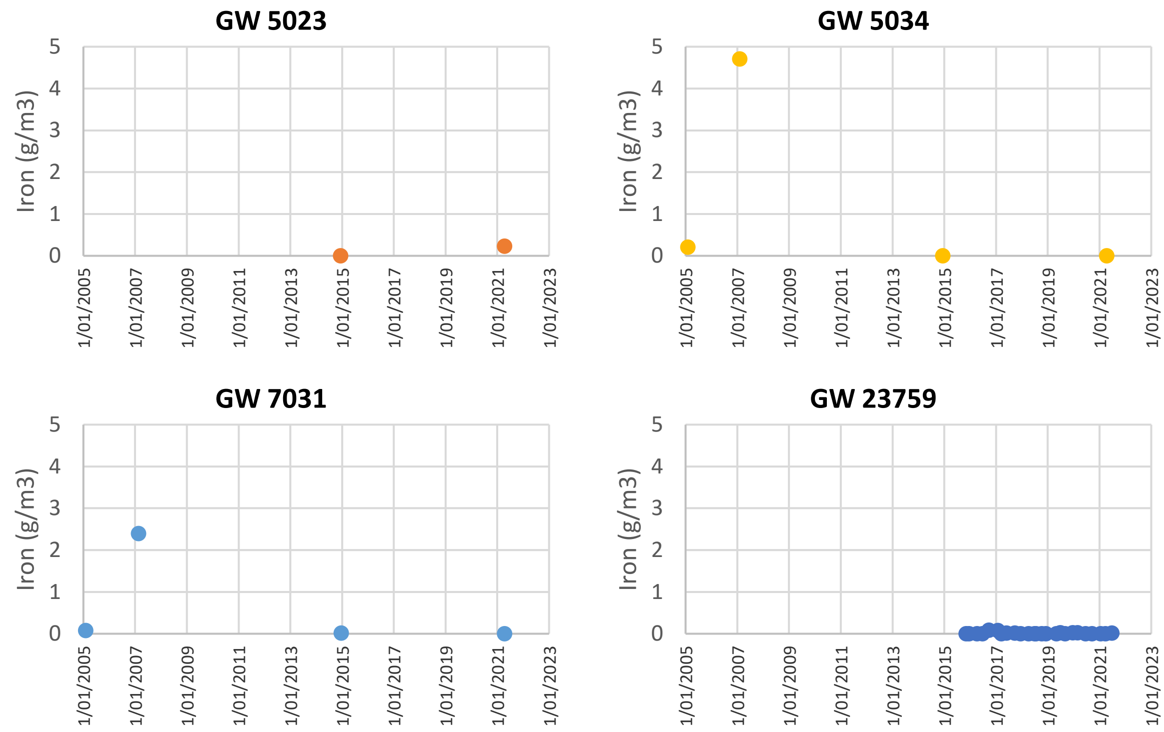


Figure 7: Measured iron concentrations over time for the Aorere/West Coast.

Nitrate-N (g/m³-N)

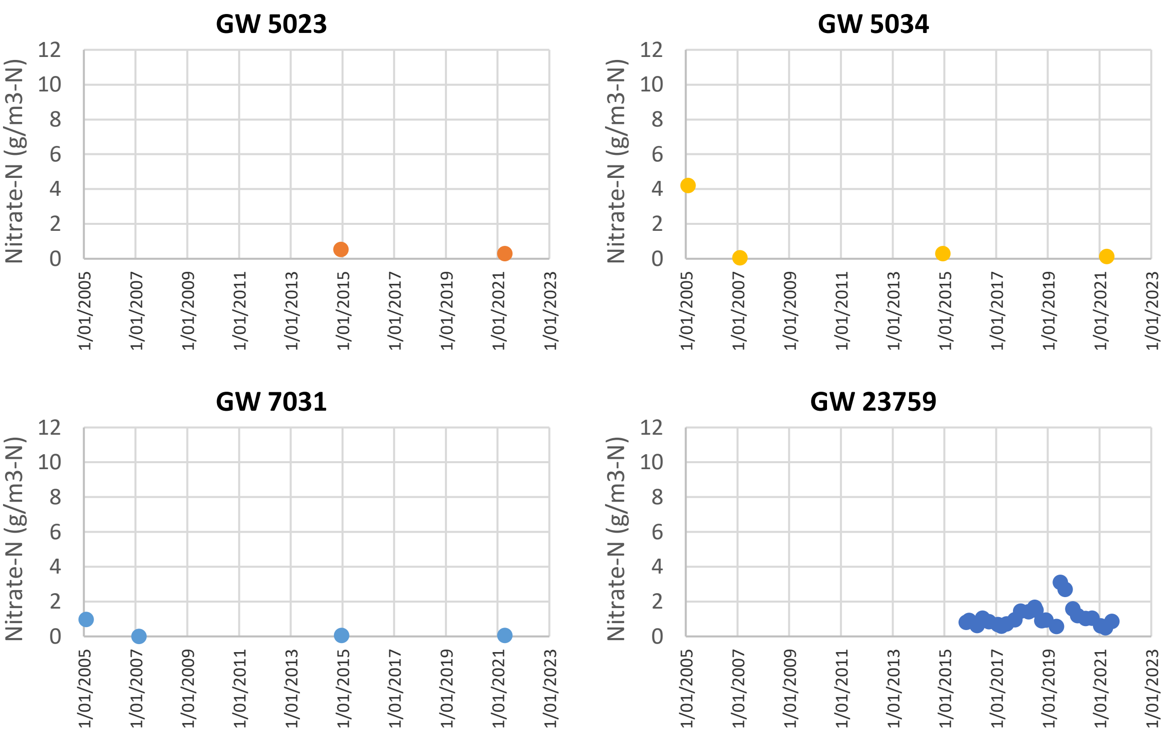


Figure 8: Measured nitrate-N concentrations over time for the Aorere/West Coast.

pH (pH units)

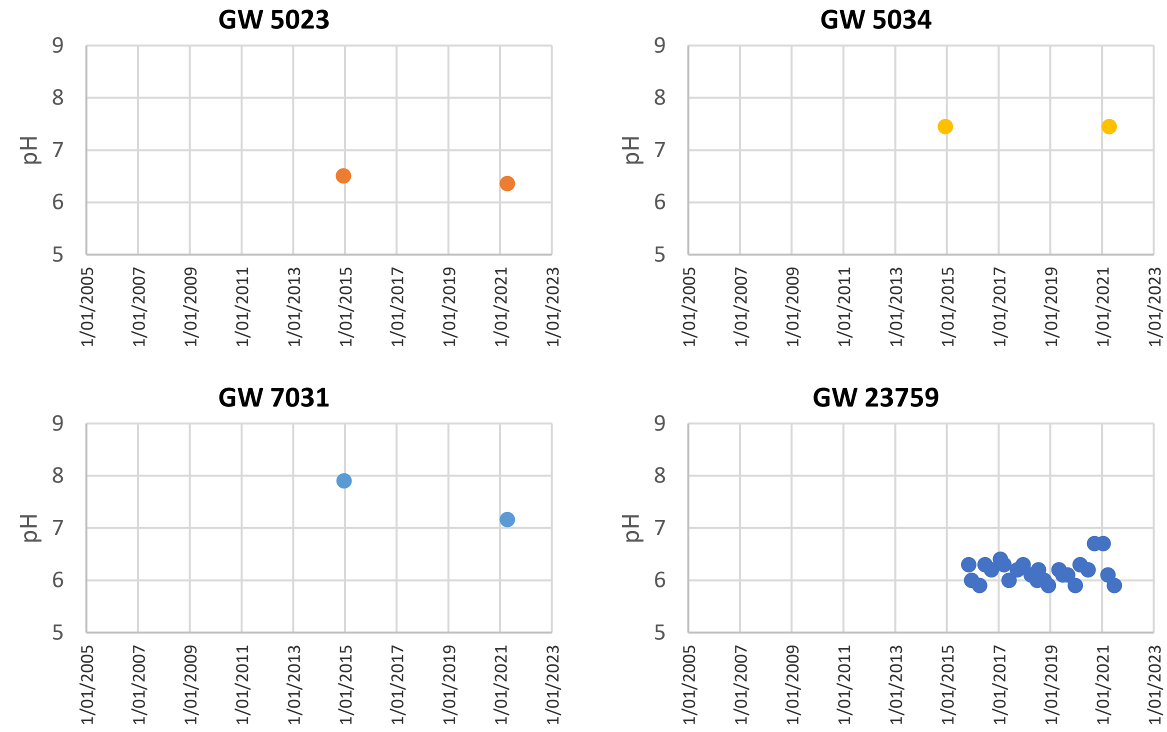


Figure 9: Measured pH concentrations over time for the Aorere/West Coast.

Water Temperature (°C)

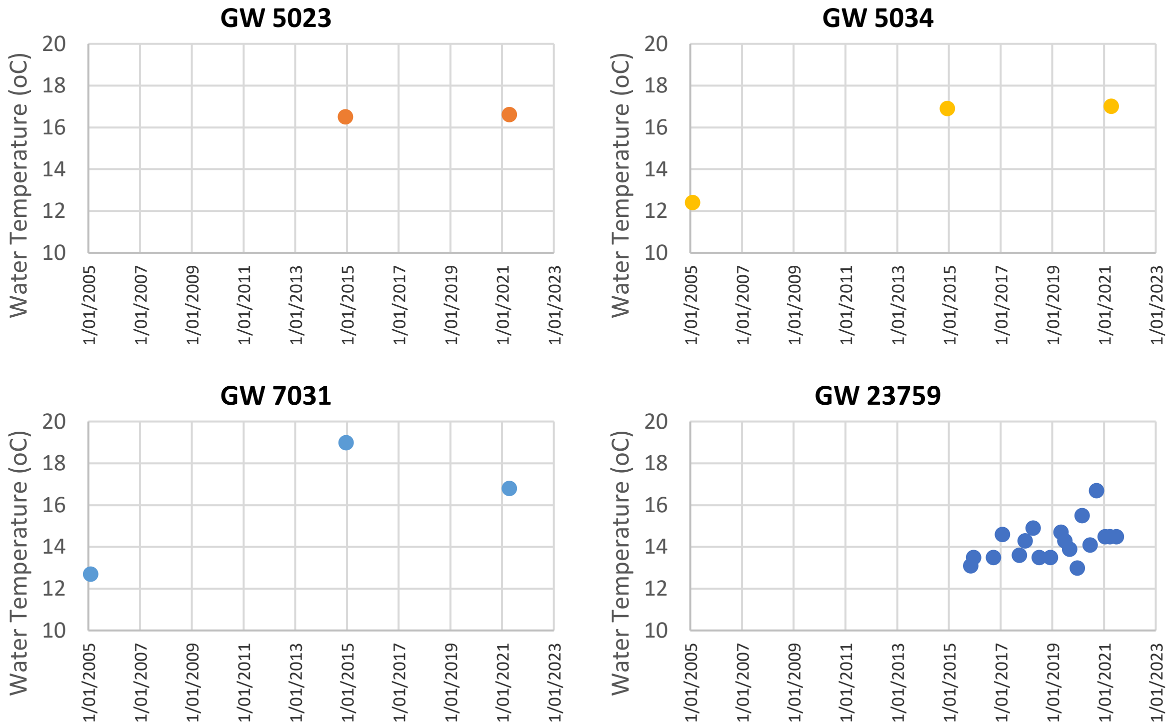


Figure 10: Measured temperature data over time for the Aorere/West Coast.

Overall, there has been little change in groundwater quality throughout the years, with most sample parameters below the MAV and GV for the DWSNZ. Comparing the synoptic survey results against the long term SoE monitoring bore shows little change in groundwater quality. *E.coli* was the only parameter to exceeded the DWSNZ MAV in the shallow bores/wells throughout the years. *E.coli* is not currently tested for at GW 23759 – Collingwood as part of the SoE long term monitoring. This is because GW 23759 – Collingwood is part of the Council reticulated water supply well field for Collingwood and is chlorinated to remove *E.*coli at the water treatment plant (Tasman District Council, 2022).

Aside from *E.coli*, groundwater quality for the majority of parameters has historically been below the DWSNZ MAV and GV. The 2021 synoptic survey indicate that the sample parameters continue to remain below the DWSNZ MAV and GV at the time of sampling.

2.3 National Groundwater Pesticide, Glyphosate and Emerging Organic Contaminants Investigation

Since 1998, the Institute of Environmental Science and Research (ESR) has conducted a groundwater investigation sampling every four years for pesticides in bores across New Zealand. In 2018, ESR sampled for glyphosate (commonly known as 'RoundUp' or 'Drexel') and emerging organic contaminants (EOCs) for the first time, alongside the pesticide sampling.

One bore in the Aorere/West Coast Water Management Zone was sampled in 2018 as part of this investigation. This was the long-term monitoring bore (GW 23759 – Collingwood). As the bore was included into the Council State of the Environment quarter-yearly groundwater monitoring programme in 2015, the 2018 sampling was the first time that GW 23759 – Collingwood had been included in the ESR national groundwater investigation. There were no pesticides, glyphosate or EOCs detected in GW 23759 – Collingwood at the time of sampling (Close & Humphries, 2019).

3. SURFACE WATER QUALITY

As with the groundwater sites, various chemical parameters for the surface water sites were tested, see Appendix I and II for the full suite of parameters tested for and the sampling methodology respectively. The surface water sites were analysed against a selection of attribute states in the National Policy Statement for Freshwater Management (NPSFM) (2020) for the protection of river ecosystem health.

Appendix 1B Part 2 of the NPSFM requires the FMU or part of the FMU has "water quality and quantity [that] is sufficient for water to be taken and used for drinking water supply" (NPSFM, 2020). The results of the 2021 sampling were compared against the DWSNZ for the MAV parameters. Please refer to Appendix III to see the distribution of selected chemical parameters across the Aorere/West Coast Water Management Zone and Appendix VIII to see a breakdown of the parameters in relation to the site location.

Care is required in interpreting the results. Most of the NPSFM parameters require multiple samples to be taken throughout the year to determine the appropriate attribute state. For most of the synoptic survey rivers/springs, this was the first time that they have been sampled. The results are representative of the water quality that was present on the day and time that the sample was taken (can be thought of as a snapshot in time of the water quality). Water quality can vary seasonally due to a range of factors including changes in rainfall patterns (volume and intensity) and land use practices throughout the year. It is impossible to establish any long-term quality trends from a single sample.

On average the surface water was of good quality when compared to NPSFM attribute state values and the DWSNZ MAVs. All 16 rivers recharge the underlying aquifer system. The Aorere River is likely to provide significant recharge to the Aorere valley, with the other rivers providing localised in the areas near those rivers.

Most of the rivers and springs appear to have a water quality state aligned with the NPSFM attribute state A. The springs appear to have slightly less water quality state, and aligned mostly in the attribute state B or C. Most of the NPSFM attribute states require long term monitoring to produce annual median or annual 95th percentile results. The analysis from this survey is based off a single water quality sample so actual attribute states cannot be accurately determined from this data.

Four of the surface water samples were taken along the Aorere River, starting inland with the site at Heaphy track and progressing through the Aorere valley towards the coast with the site at Le Compte in the lower Aorere valley. Nitrate-N concentrations increase as the Aorere River travels towards the coast (see Figure 11). However, the increase in Nitrate-N along the Aorere River is still within the NPSFM attribute state A.

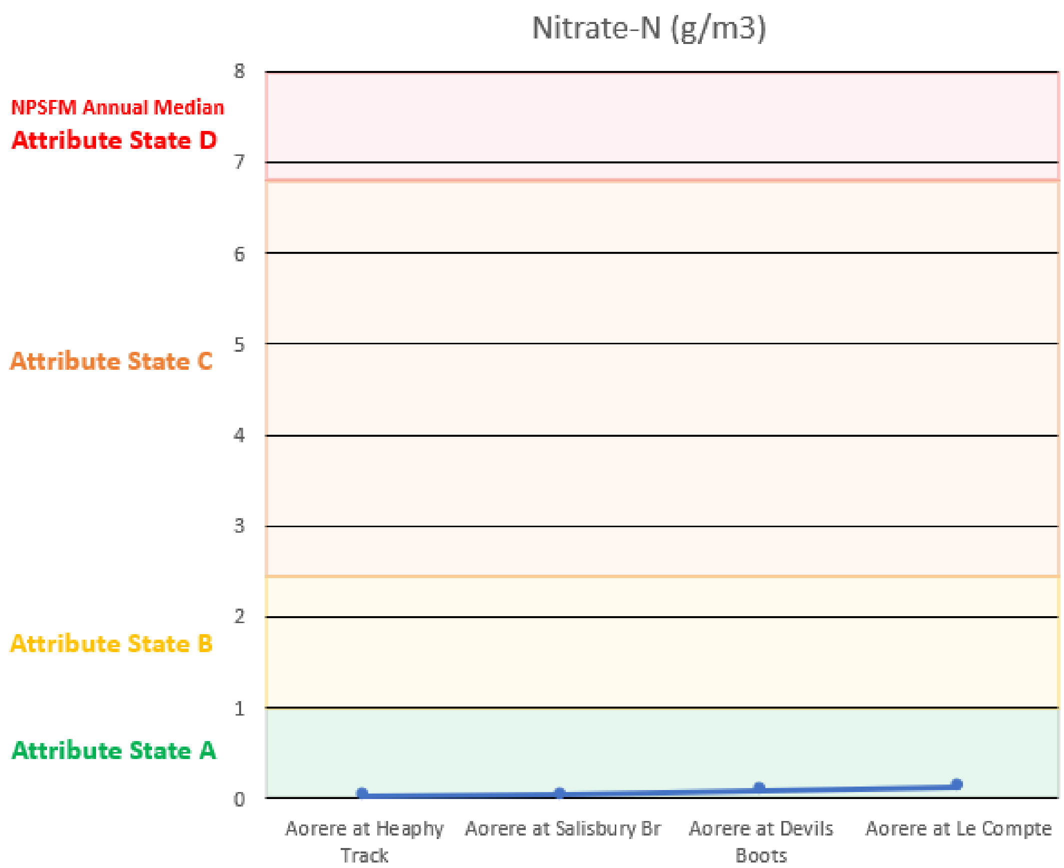


Figure 11: Concurrent nitrate-N concentrations along the Aorere River.

E.coli was the only DWSNZ parameter in the rivers and springs to exceed the maximum acceptable value for health significance. The inland rivers seem to have lower *E.coli* concentrations compared to coastal rivers. Springs inland seem to have higher *E.coli* concentrations compared to the one coastal spring.

Spring water can be slightly lower in quality than water taken directly from the aquifer. The gradient of the land where springs emerge are usually shallow, which causes the water to flow slowly. This allows the water to pool in some places and become stagnant. This can be seen by comparing the *E.coli* concentrations between the rivers and spring. A possible reason for higher *E.coli* in springs could be due to the ponded water attracting wildlife and birds which defecate directly into the water. Rivers generally have higher flows with aeration (riffles) allowing for greater dilution, better exposure to ultra-violet light (UV), with less opportunity for stagnation and ponding. Most of the springs sampled also had poor riparian planting (which help to filter water from overland runoff and also provides shading to the spring). In contrast, most of the rivers had good riparian planting which provided shading.

4. DISCUSSION

The main aquifer in the Aorere/West Coast Water Management Zone is in the Aorere valley river terraces. Water bearing gravels in the valley are between 6 to 20 m deep. The aquifer is recharged by the Aorere River and rainfall. There is localised recharge by side contributing valleys. Rainfall recharge and to a lesser degree overland infiltration also occurs away from the main river stem. Outside of the Aorere valley, there is localised groundwater in alluvial and colluvial gravel outwash along the coast and is recharged by rivers, rainfall and overland infiltration. Some of these river reaches go dry over the summer months. Most of the bores and wells in the Aorere/West Coast are shallow and access groundwater between 4 to 8 m below ground level.

Overall, groundwater in the Aorere/West Coast Water Management Zone is of good quality with regards to water chemistry. The 2021 survey found the majority of the chemical parameters were well below the DWSNZ for both the health significant and aesthetic factors. River water quality, which is the main source of recharge for the Aorere/West Coast Water Management Zone is also of good quality.

Groundwater in the inland Aorere valley is slightly acidic, with the pH neutralising and becoming slightly basic along the eastern side valleys due to limestone intrusions in the Haupiri Range. Limestone intrusions in the Burnett and Wakamarama Ranges also raises the pH for both groundwater and surface water between Ruataniwha Inlet and Pākawau and along the western coastline.

Coastal sites were generally higher in conductivity than inland sites. The higher coastal conductivity readings are associated from sampling near a high tide. Inland sites had no statistical difference between shallow and deep groundwater.

All river sites had dissolved oxygen of 50% or higher (most were around 100%). Spring sites were slightly lower (between 25 – 75%), though this was expected due to a lesser gradient and therefore less aeration. Most dissolved oxygen in the groundwater was similar to that of surface water (between 50 – 100%). There was an area of low dissolved oxygen (less than 50%) where the Aorere River discharges into Golden Bay through the swampy Ruataniwha Inlet. Some groundwater sites had dissolved oxygen of less than 20% indicating reducing, anaerobic conditions.

Iron and manganese concentrations near the Ruataniwha Inlet were elevated, with most at or approaching the DWSNZ GV or MAV. Elevated iron and manganese concentrations are common under reducing conditions. Some of the bores north of Pākawau abstracting mineralised water from deeper alluvial gravel outwash also had elevated iron and manganese concentrations. In the rest of the Aorere/West Coast, iron and manganese were low, with most groundwater and surface water sites below the limit of detection.

The majority of shallow coastal and inland groundwater sites had a total hardness of between 20 – 150 g/m3 as $CaCO_3$. Groundwater sourced deeper below the ground surface had a total hardness between 25 – 30 g/m^3 as $CaCO_3$. Low hardness in combination with slightly acidic groundwater (particularly around the Ruataniwha Inlet where there are also reducing conditions present), means the groundwater in the Aorere/West Coast Water Management Zone can be corrosive. The Council reticulated water supply for Collingwood is corrected for pH to mitigate this issue.

All nitrate-N for groundwater and surface water sites were below the DWSNZ MAV. Groundwater sites were generally higher than surface water sites. Nitrate-N in inland springs were slightly higher than all other surface water sites. Four groundwater sites were above half of the DWSNZ MAV (above 5.6 g/m^3-N), however were still below the MAV (11.3 g/m^3-N). Low nitrates are common when reducing conditions are present (near the Ruataniwha Inlet).

There was no pesticides, glyphosate or EOCs detected by ESR in 2018 in the long term monitoring bore located in the lower Aorere valley. Comparisons to bores/wells in the eastern coastal settlements which have been sampled in previous synoptic surveys remain of good quality, with no significant changes throughout the years.

The 2021 water quality investigation did identify various risks to the security of the unconfined / semiconfined (leaky) aquifer which could have health risks to public health. These include inappropriate sitting of bores/wells and bore/well heads not fully sealed. In most instances these were not intentional but more a lack of knowledge.

Localised contamination of *E.coli* was common in the shallow groundwater sites, both inland and coastal sites. *E.coli* contamination is likely occurring due to inappropriate bore/well siting where the bore/well was in close proximity with activities involving faecal matter (e.g. runoff from milking sheds or seepage from septic tanks). Poor bore/well head protection where the bore/well head was not sealed could also be a pathway for contamination to enter into the aquifer.

Groundwater abstracted from deeper in the aquifer (bores deeper than 10 m below ground level) did not have detections of *E.coli* at the time of sampling. All of the deep bores had good bore head protection and were appropriately sited away from potential contamination sources. *E.coli* was the only DWSNZ parameter in the rivers and springs to be exceeded. Inland rivers had lower *E.coli* concentrations compared to coastal rivers. Inland springs had the highest *E.coli* concentrations out of the surface water sites.

The 2021 Aorere/West Coast water quality investigation, along with further groundwater and surface water hydrological investigations, will be incorporated into an Aorere/West Coast FMU Water

Resources Report. The water resources report will inform the development of a water quality and quantity management plan for the Aorere/West Coast Water Management Zone.

5. REFERENCES

Close, M. and Humphries, B. (2019). *National survey of pesticides and emerging organic contaminants (EOCs) in groundwater 2018*. https://research.esr.cri.nz/articles/book/National_survey_of_pesticides_and_emerging_organic_contaminants_EOCs_in_groundwater_2018/9937304 (Downloaded 16 August 2021).

Land Air Water Aotearoa (2020). *Factsheet: Electrical conductivity*. https://www.lawa.org.nz/learn/factsheets/electrical-conductivity/ (Downloaded 16 August 2021).

Ministry for the Environment (2020). *National Policy Statement for Freshwater Management 2020*. https://environment.govt.nz/publications/national-policy-statement-for-freshwater-management-2020/ (Downloaded 16 August 2021).

Ministry of Health (2018). *Drinking-water Standards for New Zealand 2005 (Revised 2018).* Wellington, New Zealand.

New Zealand Hydrological Society (2001). *Groundwaters of New Zealand*. ISBN 0-473-07816-3. Chapter 21: Tasman, pp 423 – 424. Christchurch, New Zealand.

Tasman District Council. (2021a). *Growth model.* https://www.tasman.govt.nz/my-council/key-documents/more/growth/growth-model/ (Downloaded 6 January 2022).

Tasman District Council. (2022). *Drinking water quality and testing.* https://www.tasman.govt.nz/my-property/water/water-supply/drinking-water-quality/ (Downloaded 16 August 2021).

APPENDIX I

In April 2021, 28 groundwater sites and 21 river and spring sites were sampled.

The groundwater sites were analysed for the following parameters:

- Acidity
- Bromide
- Chloride
- Dissolved Calcium
- Dissolved Iron
- Dissolved Magnesium
- Dissolved Manganese
- Dissolved Potassium
- Dissolved Reactive Phosphorus
- Dissolved Sodium
- Electrical Conductivity
- Escherichia coli
- Free Carbon Dioxide
- Fluoride
- Nitrite-N
- Nitrate-N
- Reactive Silica
- Sulphate
- Total Alkalinity
- Total Ammonical-N
- Total Coliforms
- Total Hardness

The surface water sites were analysed for the same parameters as the groundwater sites, with the addition of Dissolved Mercury.

Each groundwater and surface water site had three bottles which required filling.

Table 2: Sample bottle treatments

Bottle	Material	Preservative
Groundwater site		
1 x 500 mL (UP500)	Polyethylene	None
1 x 100 mL (NWU100)	Polyethylene	None
1 x 400 mL (SterThio)	PET container, PP lid	$Na_2S_2O_3$
Surface Water site		
1 x 500 mL (UP500)	Polyethylene	None
1 x 100 mL (NWU100)	Polyethylene	None
1 x 400 mL (SterThio)	PET container, PP lid	None

APPENDIX II

Groundwater sampling methodology:

Each sample was taken directly from the sampling tap or pump outlet. The supply was left to run either from an existing pump or a portable pump, via a hose or directly to the ground, for a minimum duration of five but preferably up to 10 minutes for the shallow sites. Deeper groundwater sites were pumped for a minimum of three full purge volumes. Using a YSI ProDSS, conductivity, dissolved oxygen and temperature (and if possible, pH and oxygen reduction potential) were measured by filling (and overflowing) a bucket so the probes received constant flow over the sensors.

After pumping, the sampling tap/outlet was cleaned using a paper towel sprayed with methylated spirits, followed by disinfection using flame (where possible). The tap/outlet was then run for a few seconds to allow any water impacted by the cleaning process to flush out. The water sample was filled directly into the bottles from the tap/outlet. Unpreserved bottles were filled directly to the top of the bottle. Preserved bottles were filled to 1 cm below the rim of the bottle so none of the preservative which coated the inside of the bottle was lost by overfilling for spilling.

The filled bottles were then labelled and bagged to keep all the bottles from each site together. Once bagged, the samples were placed in a chilly bin, kept cool with ice packs and couriered overnight to Hill Laboratories. Samples which required filtering for analysis were filtered by Hill Laboratories directly.

River and spring sampling methodology:

The river and spring samples were taken using a simple grab method, where the sample bottles and lid were dipped into the water until they were filled. The lid was screwed underwater to avoid any surface water scum entering the sample. The field measurements were taken by dipping the probes into the main flow of the water.

APPENDIX III

Distribution of selected chemical parameters across the Aorere/West Coast Water Management Zone.

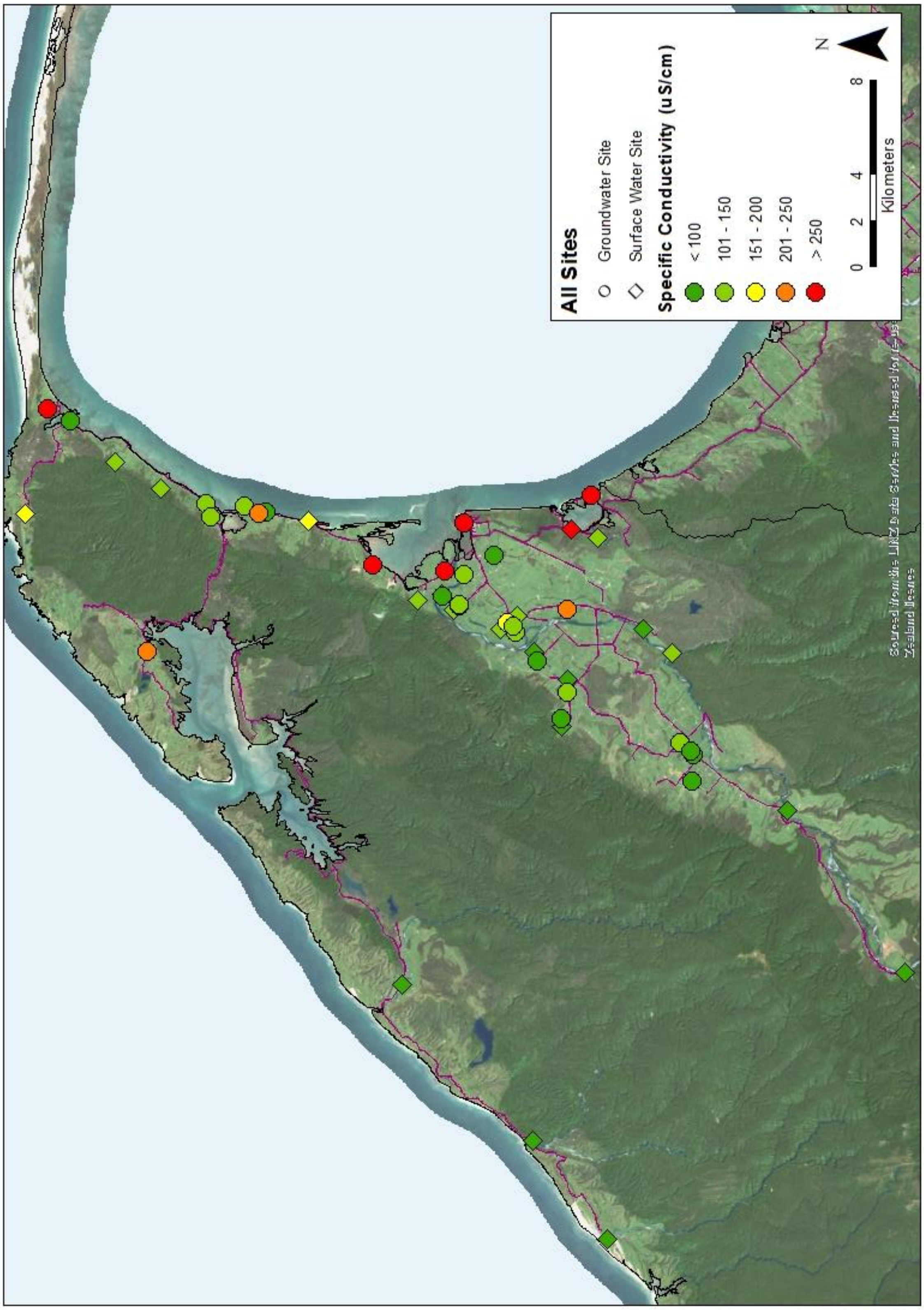


Figure 12: Distribution of conductivity across Aorere/West Coast from 2021 survey.

There is no DWSNZ MAV or GV for conductivity.

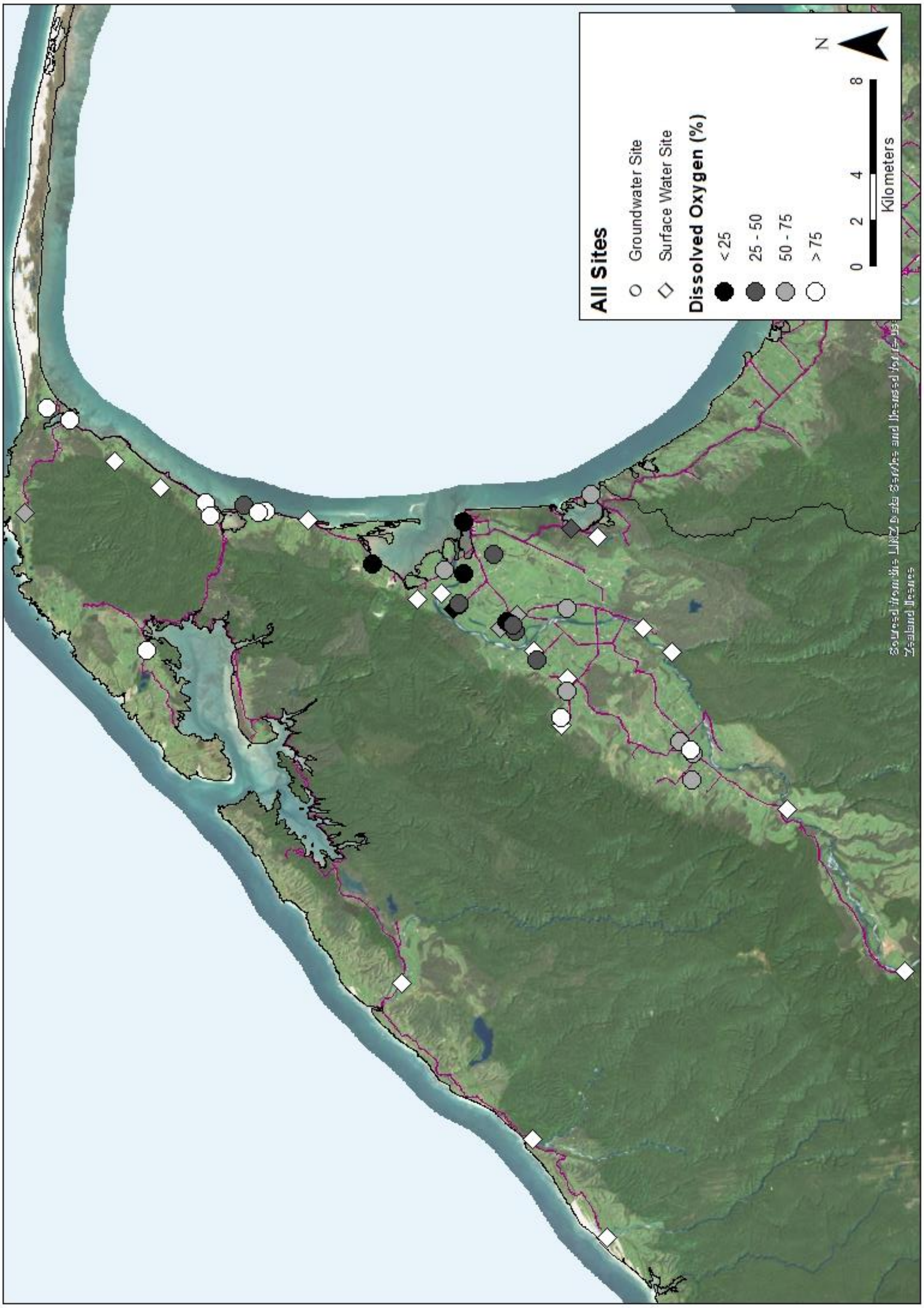


Figure 13: Distribution of dissolved oxygen across Aorere/West Coast from 2021 survey.

There is no DWSNZ MAV or GV for dissolved oxygen.

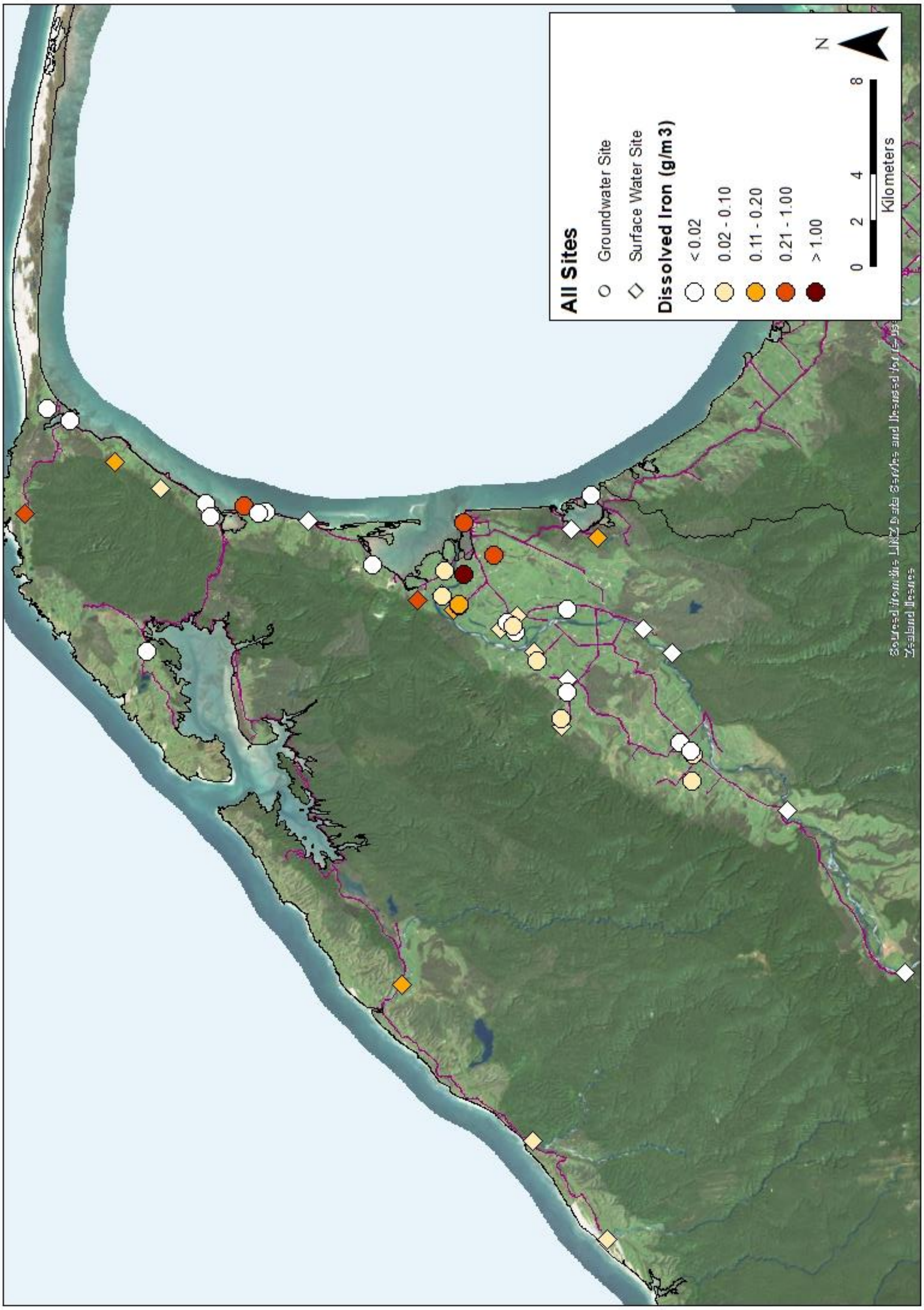


Figure 14: Distribution of iron across Aorere/West Coast from 2021 survey.

The DWSNZ GV for iron is 0.20 g/m^3.

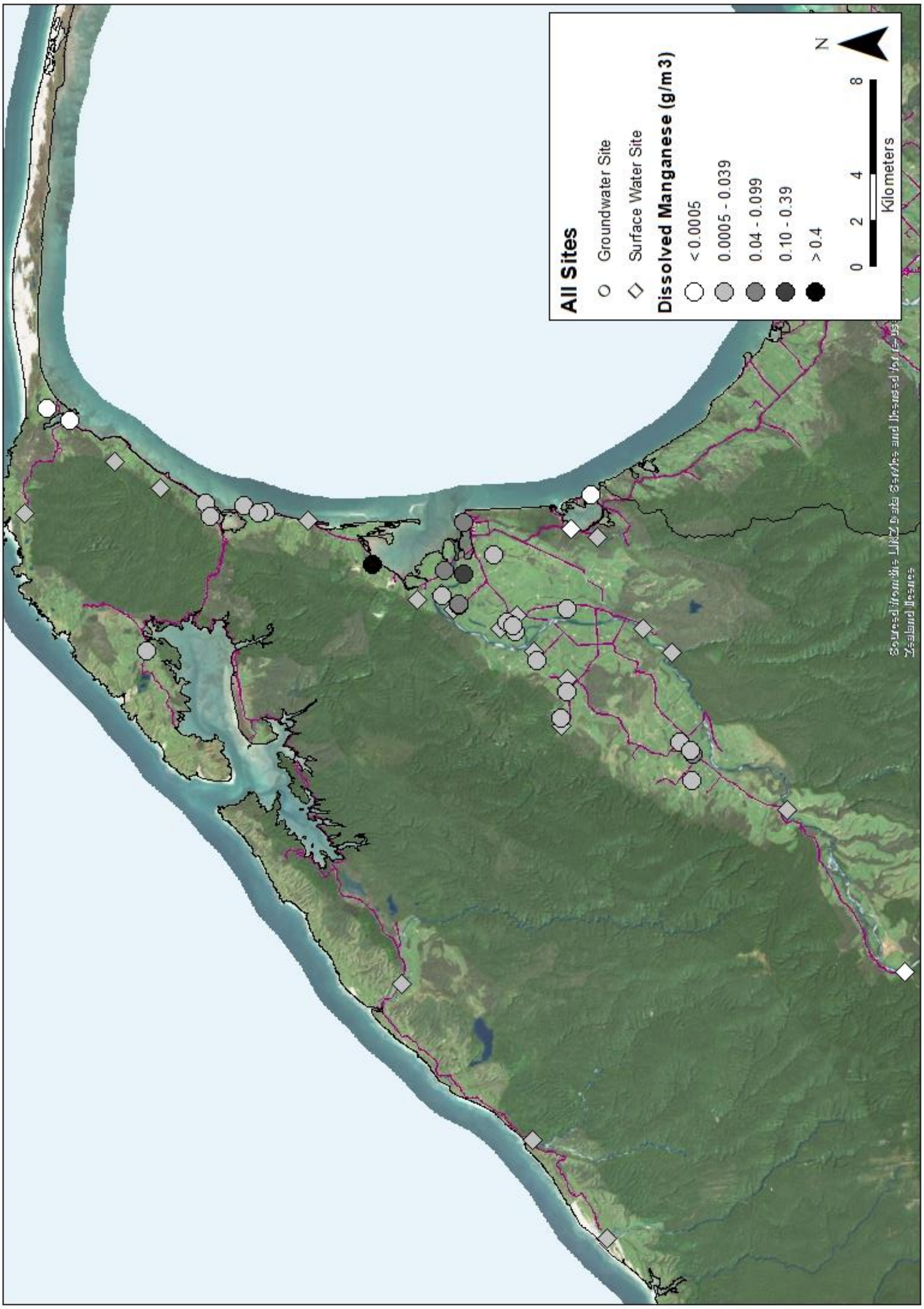


Figure 15: Distribution of manganese across Aorere/West Coast from 2021 survey.

The DWSNZ MAV for manganese is 0.4 g/m^3. The DWSNZ GV for manganese is 0.04 g/m^3 (staining of laundry), 0.10 g/m^3 (taste threshold).

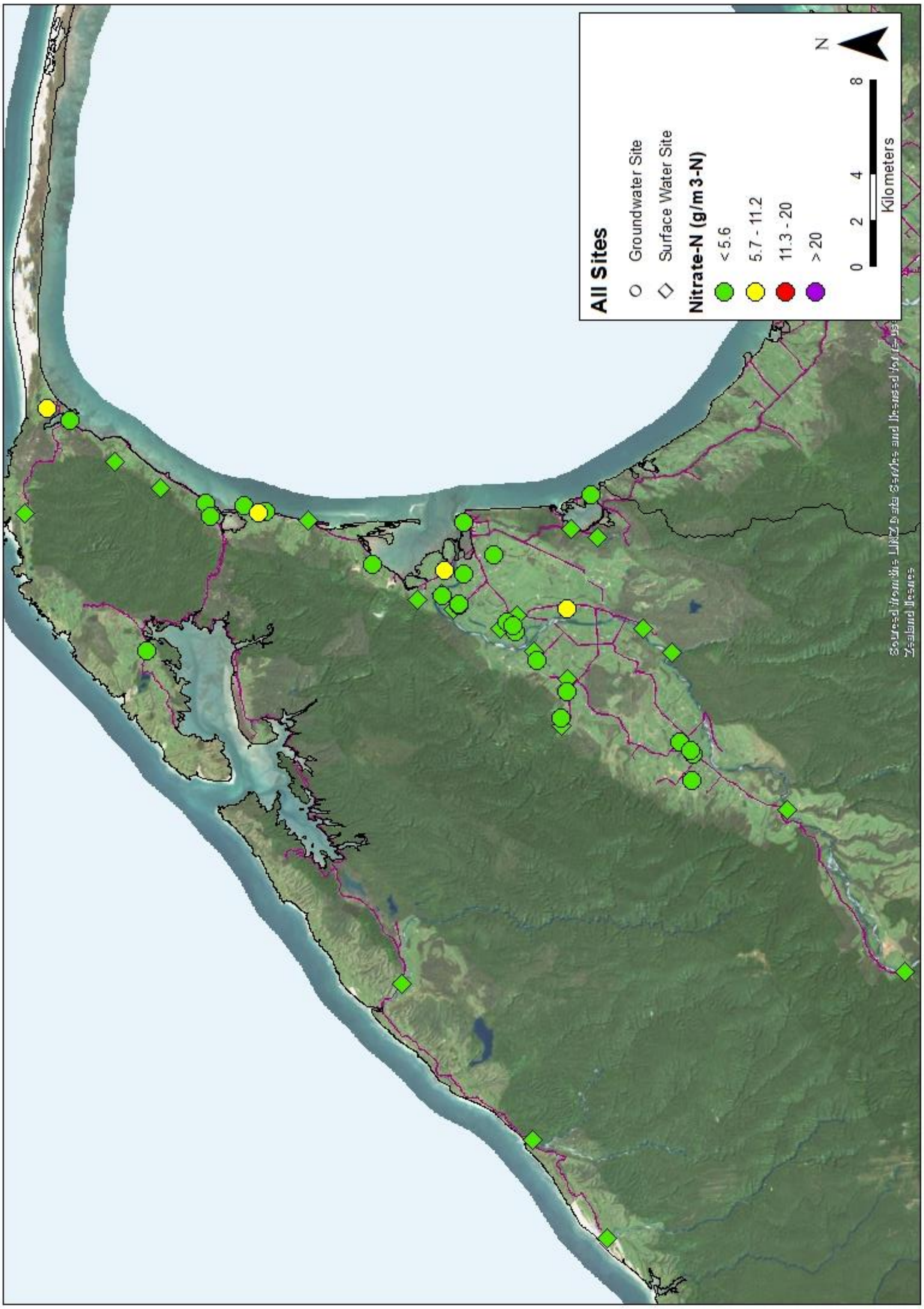


Figure 16: Distribution of nitrate-N across Aorere/West Coast from 2021 survey.

The DWSNZ MAV for nitrate-N is 11.3 g/m^3-N.

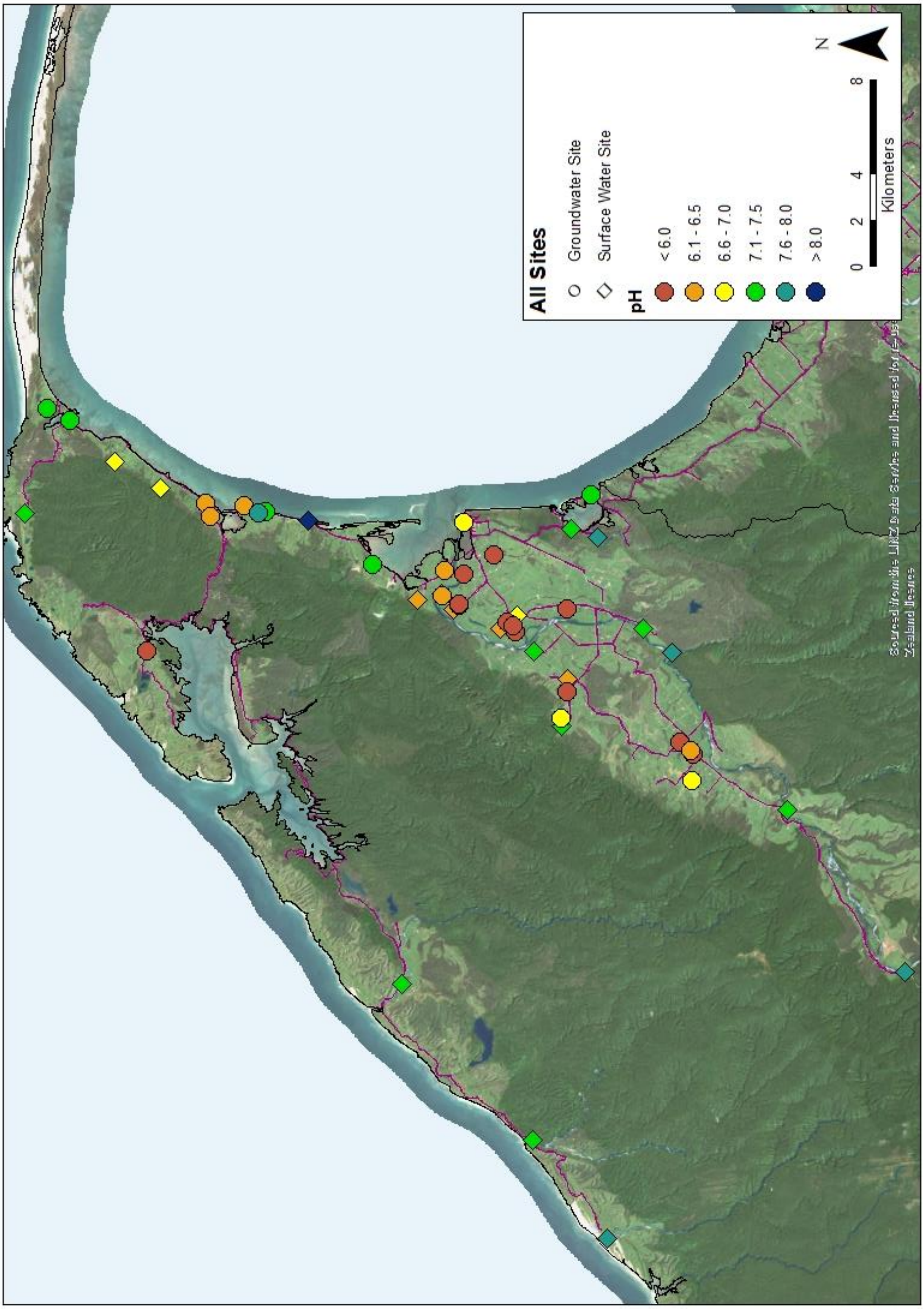


Figure 17: Distribution of pH across Aorere/West Coast from 2021 survey.

The DWSNZ GV for pH is between 7.0 and 8.5 pH units.

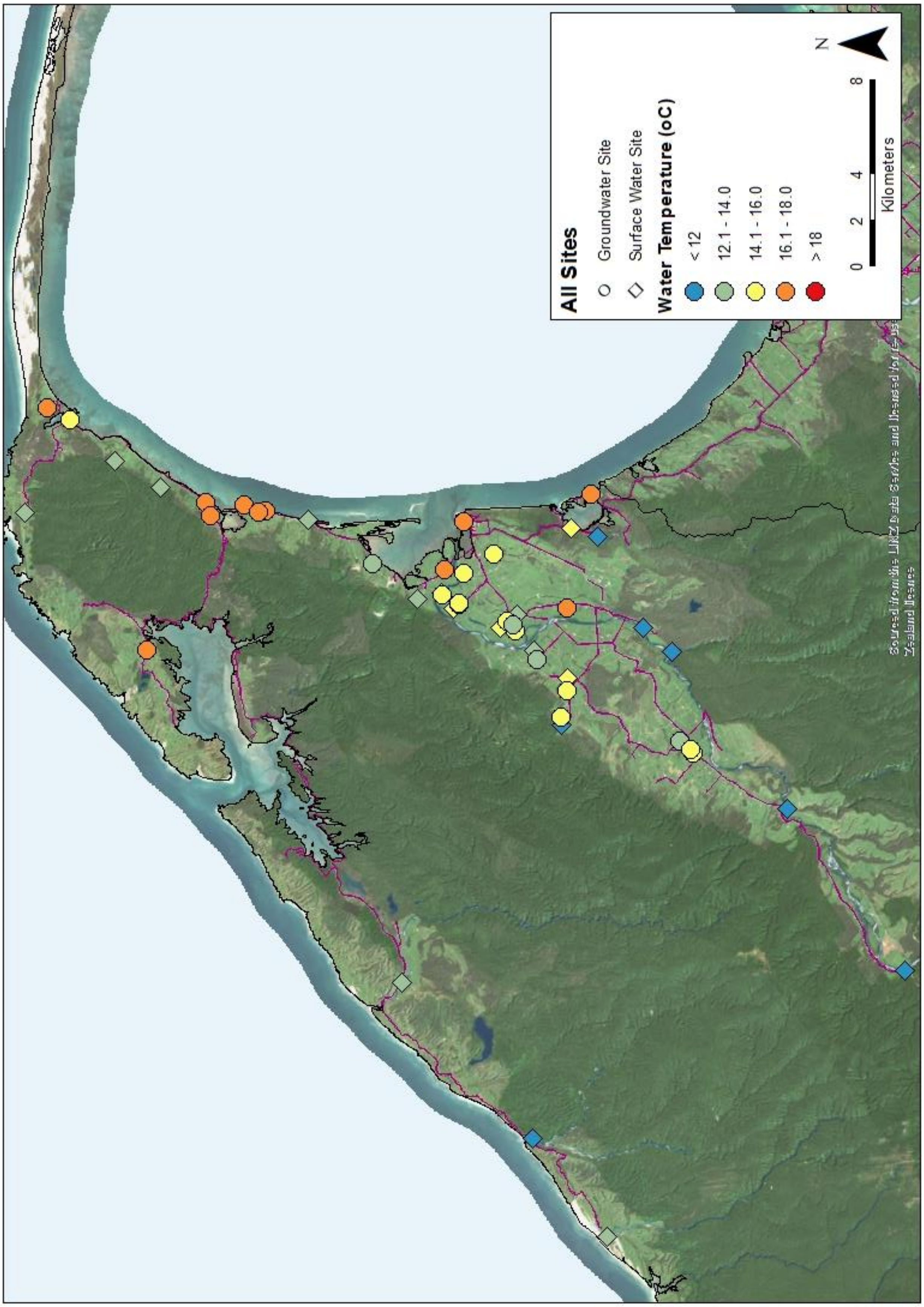


Figure 18: Distribution of temperature across Aorere/West Coast from 2021 survey.

There is no DWSNZ MAV or GV for temperature.

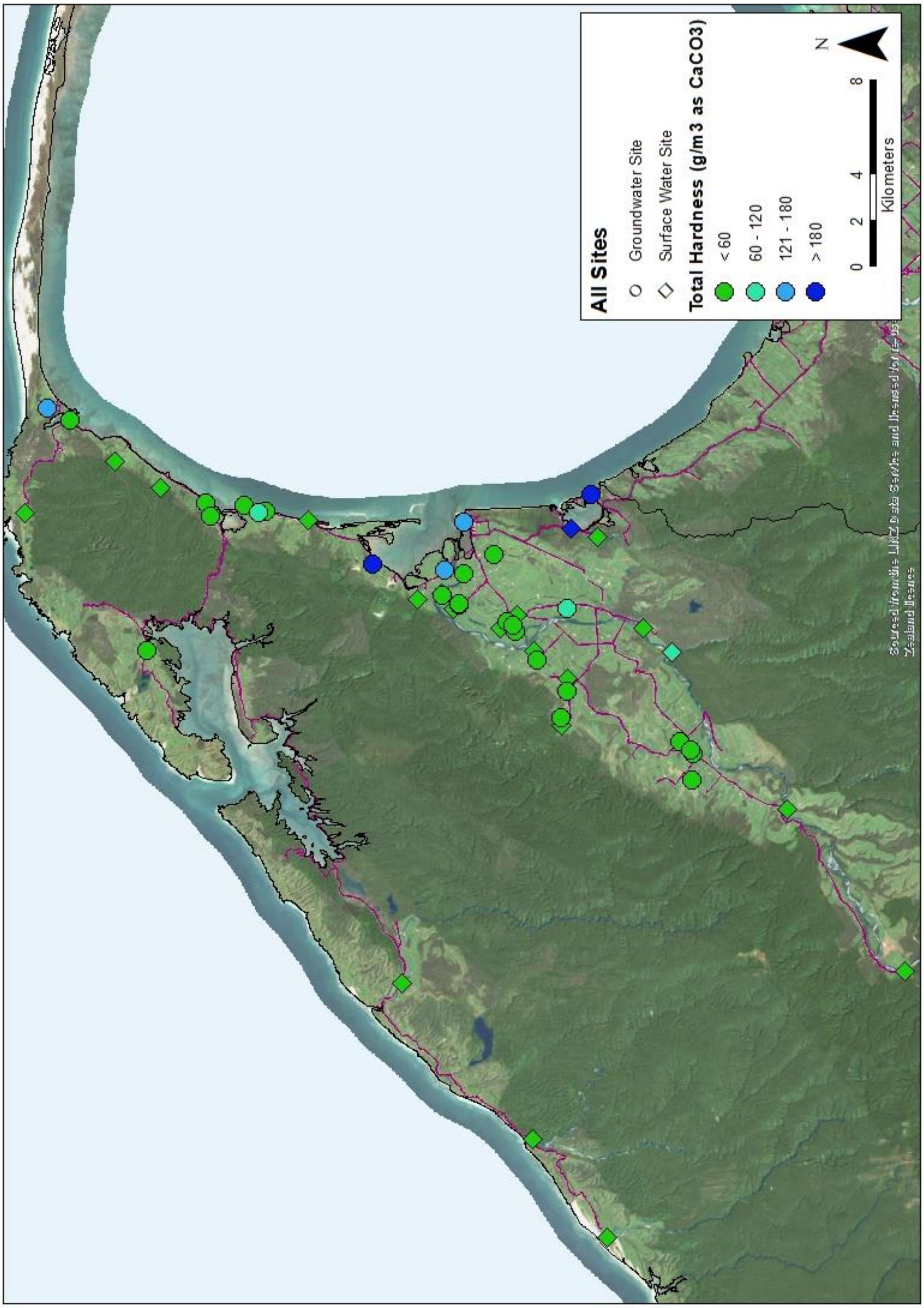


Figure 19: Distribution of total hardness across Aorere/West Coast from 2021 survey.

The DWSNZ GV is 200 g/m^3 as $CaCO_3$. Taste threshold is 100 – 300 g/m^3 as $CaCO_3$.

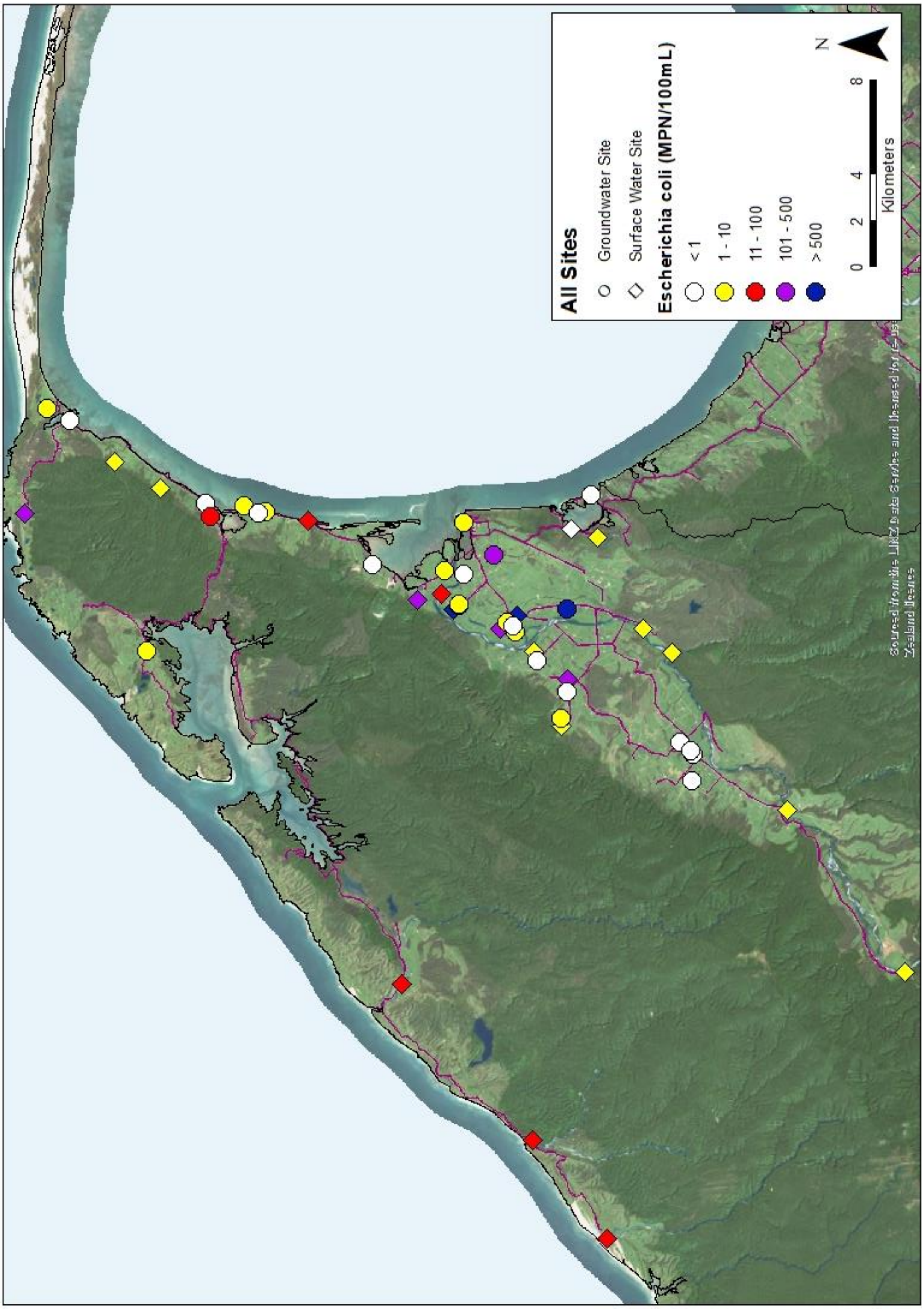


Figure 20: Distribution of E.coli across Aorere/West Coast from 2021 survey.

The DWSNZ MAV for *Escherichia coli* is < 1 MPN/100mL.

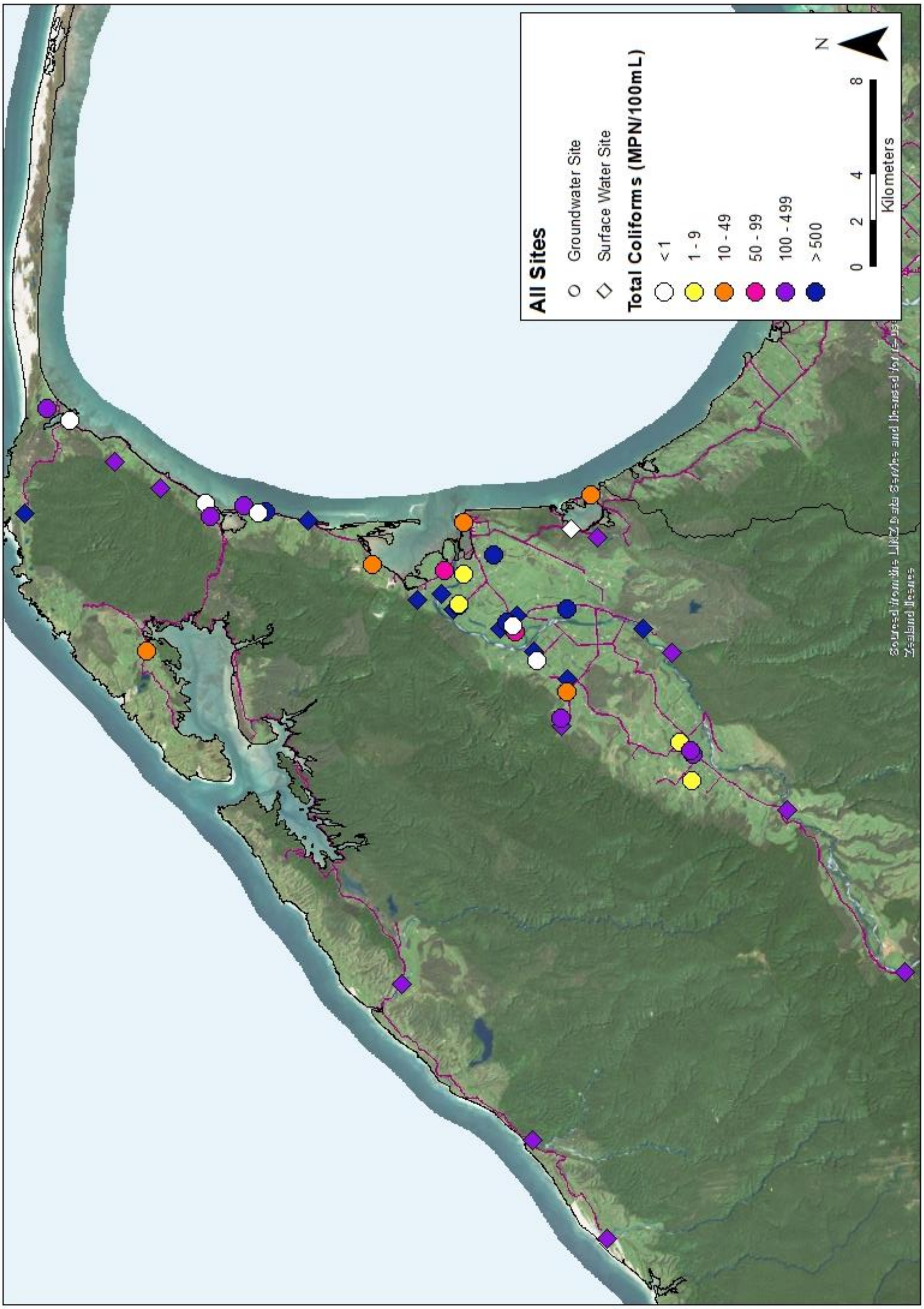


Figure 21: Distribution of total coliforms across Aorere/West Coast from 2021 survey.

There is no DWSNZ MAV or GV for total coliforms.

APPENDIX IV

Health significant, aesthetic and bacteriological parameters for the 2021 Aorere/West Coast groundwater sites.

Care is required in interpreting the results. For most of the synoptic survey bores/wells, this was the first time that they have been sampled. The results are representative of the water quality that was present on the day and time that the sample was taken (can be thought of as a snapshot in time of the water quality). Water quality can vary seasonally due to a range of factors including changes in rainfall patterns (volume and intensity), river recharge and land use practices throughout the year. It is impossible to establish any long-term quality trends from a single sample.

Table 3: Health Significant parameters for 2021 Aorere/West Coast groundwater sites

Parameter	DWSNZ (MAV)	Findings
Fluoride	1.5 g/m^3	*Coastal*: All sites below 50% MAV. Two sites above 10% of MAV. The rest below limit of detection. *Inland*: Three sites below 10% of MAV. The rest below limit of detection. *Deep*: Two sites below 10% of MAV. The rest below limit of detection.
Manganese	0.4 g/m^3	*Coasta*l: All sites below 50% of MAV. Three sites above 10% of MAV. Four sites below 10% of MAV. The rest below limit of detection. *Inland*: All sites below 50% of MAV. One site above 10% of MAV. The rest below 10% of MAV. *Deep*: One site exceeded MAV (site had reading of 0.45 g/m^3). The rest below 10% of MAV.
Nitrite-N	0.91 g/m^3-N (short term)	*Coastal*: All sites below MAV. Three sites below 10% of MAV. The rest below the limit of detection. *Inland*: All sites below MAV. One site below 10% of MAV.

		The rest below the limit of detection. *Deep*: All sites below the limit of detection.
Nitrate-N	11.3 g/m^3-N (short term)	*Coastal*: All sites below MAV. Three sites above 50% of MAV. The rest below 10% of MAV. *Inland*: All sites below MAV. One site above 50% of MAV. Eight sites above 10% of MAV. The rest below 10% of MAV. *Deep*: All sites below 50% of MAV. One site above 10% of MAV. Two sites below 10% of MAV. The rest were below the limit of detection.

Table 4: Aesthetic parameters for 2021 Aorere/West Coast groundwater sites

Parameter	DWSNZ (GV)	Findings
Chloride	250 g/m^3 (Taste, corrosion)	*Coastal*: All sites below GV. Two sites above 50% of GV. Two sites above 10% of GV. The rest below 10% of GV. *Inland*: All sites below 50% of GV. One site above 10% of GV. The rest below 10% of GV. *Deep*: All sites below 10% of GV.
Conductivity	µS/cm Preferably low. For context, seawater is 50,000 µS/cm (LAWA, 2020)	*Coastal*: Majority between 100 – 600 µS/cm. The highest was 847 µS/cm. *Inland*: Majority between 50 – 150 µS/cm. *Deep*: Majority between 50 – 150 µS/cm.
Iron	0.2 g/m^3 (Staining of laundry and sanitary ware)	*Coastal*: Three sites exceeded GV (sites had readings of 5.5 g/m^3, 0.88 g/m^3 and 0.23 g/m^3). One site above 10%

		but below 50% of GV. The rest were below limit of detection. *Inland*: One site exceeded GV (site had reading of 0.61 g/m^3). Two sites were above 10% but below 50% of GV. The rest were below limit of detection. *Deep*: All sites below 50% of GV. Two sites above 10% of GV. The rest were below limit of detection.
Manganese	0.04 g/m^3 (Staining of laundry) 0.10 g/m^3 (Taste threshold)	*Coastal*: One site above the taste threshold GV. Three sites above the staining threshold GV. The rest below all GV thresholds and/or limit of detection. *Inland*: No sites above the taste threshold GV. One site above the staining threshold GV. The rest below all GV thresholds and/or limit of detection. *Deep*: One site above the taste threshold GV. The rest below all GV thresholds and/or limit of detection.
pH	7.0 – 8.5 pH units Most waters with a low pH have a high plumbosolvency (ability to dissolve lead). Waters with a high pH have a soapy taste and feel. A pH less than 8 is preferable for effective disinfection with chlorine.	*Coastal*: Majority between 6 – 7.5. Five sites were below 7. No sites were above 8. *Inland*: Majority between 5.5 – 6. All sites below 7. *Deep*: Majority between 6 – 7. Three sites below 7. No sites were above 8.
Sodium	200 g/m^3 (Taste threshold)	*Coastal*: All sites were below 50% of GV. Four sites were above 10% of GV. The rest were below 10% of GV. *Inland*: All sites were below 50% of GV. One site was above

		10% of GV. The rest were below 10% of GV. *Deep*: All sites were below 10% of GV.
Sulphate	250 g/m^3 (Taste threshold)	*Coastal*: All sites were below 50% of GV. One site above 10% of GV. The rest below 10% of GV. *Inland*: All sites were below 10% of GV. *Deep*: All sites were below 10% of GV.
Total Hardness	200 g/m^3 as $CaCO_3$ High hardness causes scale deposition, scum formation. Low hardness (< 100) may be more corrosive. 100 – 300 g/m^3 as $CaCO_3$ (Taste threshold)	*Coastal*: Majority between 20 – 150 g/m^3 as $CaCO_3$. Six sites were below 100 g/m^3 as $CaCO_3$. No sites were above 300 g/m^3 as $CaCO_3$. *Inland*: Majority between 20 – 50 g/m^3 as $CaCO_3$. All sites were below 100 g/m^3 as $CaCO_3$. *Deep*: Majority between 25 – 30 g/m^3 as $CaCO_3$. Three sites were below 100 g/m^3 as $CaCO_3$. No sites were above 300 g/m^3 as $CaCO_3$.
Temperature	^{o}C Preferably cool	*Coastal*: Majority between 15 – 17 ^{o}C. *Inland*: Majority between 14 – 16 ^{o}C. *Deep*: Majority between 13 – 16 ^{o}C.

Table 5: Bacteriological parameters for 2021 Aorere/West Coast groundwater sites

Parameter	**DWSNZ (MAV)**	**Findings**
Total Coliforms		*Coastal*: Highest coastal site was 1,553 MPN/100mL. Four sites above 100 MPN/100mL. Majority below 50 MPN/100mL. Two sites were below limits of detection.

		Inland: Highest inland site had exceeded the limit of detection (> 2,420 MPN/100mL). Four sites were above 1,000 MPN/100mL. Majority above 100 MPN/100mL. Three sites were below 20 MPN/100mL. All inland sites had Total coliforms detected. *Deep*: Highest deep site was 11 MPN/100mL. All sites were below 20 MPN/100mL. One site was below limits of detection.
Escherichia coli	< 1 MPN/100mL	*Coastal*: Six sites were above the MAV. Highest coastal site was 14 MPN/100mL. Majority below 5 MPN/100mL. Four sites were below limits of detection. *Inland*: Seven sites were above the MAV. Highest inland site was 980 MPN/100mL. Three sites above 100 MPN/100mL. Majority below 10 MPN/100mL. Four sites were below limits of detection. *Deep*: No sites were above the MAV. All sites were below limits of detection.

APPENDIX V

Geology in the Aorere/West Coast Water Management Zone.

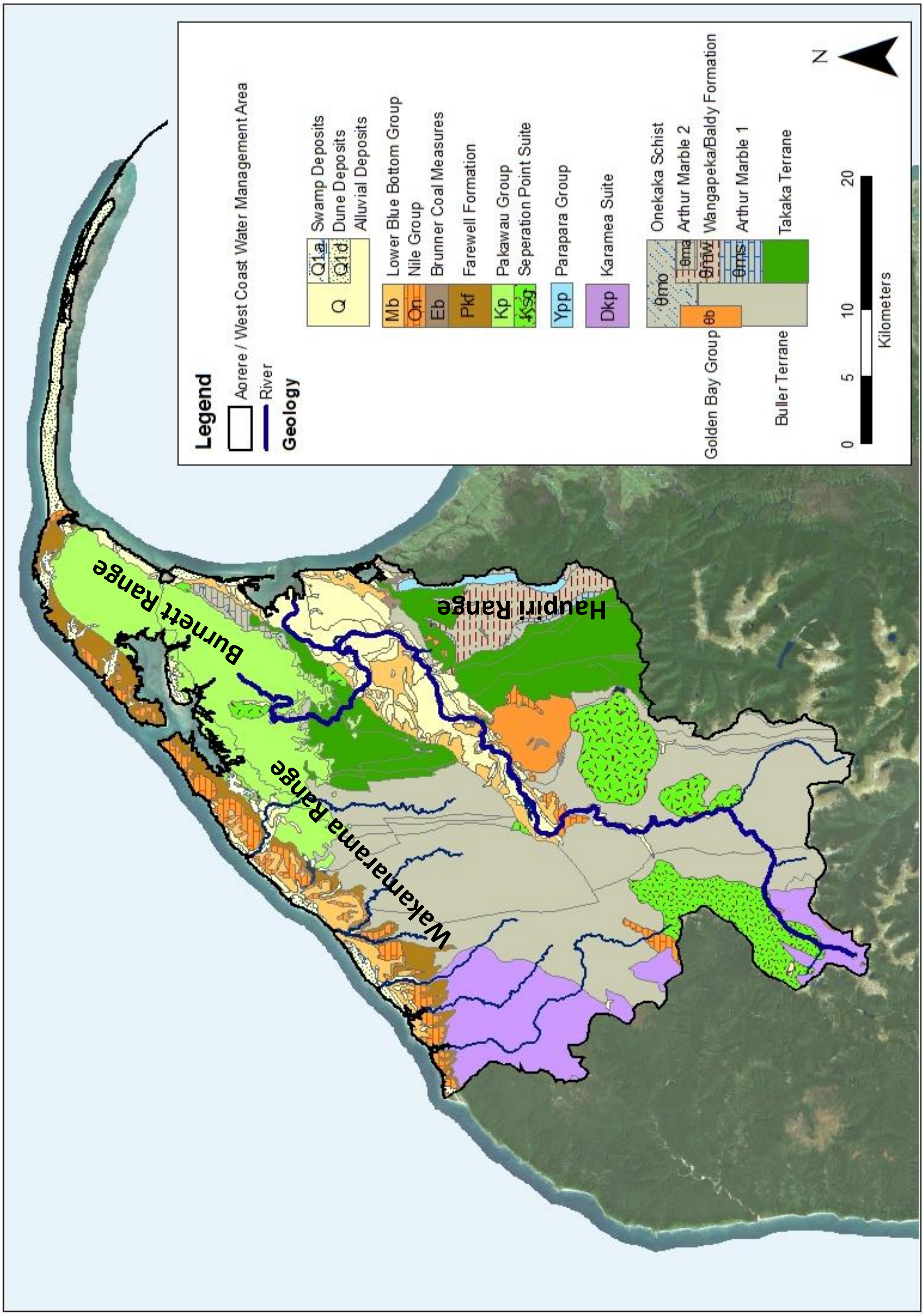


Figure 22: Geology of Aorere/West Coast Water Management Zone.

APPENDIX VI

Trends in groundwater quality in the Aorere/West Coast Water Management Zone

Table 6: Summary of trends from previous synoptic surveys and SOE monitoring bores.

Parameter	DWSNZ (MAV/GV)	Findings
Conductivity	µS/cm	Trend: No major change across the Aorere/West Coast Water Management Zone. GW 23759, located inland in the lower Aorere valley, showed no trend. The rest are located coastally and fluctuations in conductivity is likely an indication of the tide position at the time of sampling.
E.coli	< 1 MPN/100mL	Trend: No major change across the Aorere/West Coast Water Management Zone. All of the shallow bores/wells sampled in 2021 exceeded the MAV for *E.coli*. Previous surveys also have most bores/wells exceeding the MAV. Note: GW 23759 was not tested for *E.coli* as part of the 2021 survey, however this bore is one of two bores used for the Collingwood reticulated water supply network. To ensure a safe drinking water supply, Council treats the water prior to delivery to the consumer. Part of the treatment process is to remove any bacteria (such as *E.coli*) from the water via chlorine disinfection (Tasman District Council, 2022).
Iron	0.2 g/m^3 (Staining of laundry and sanitary ware)	Trend: No major change across the Aorere/West Coast Water Management Zone. GW 23759, located inland in the lower Aorere valley, had

		detections below 10% of GV. The rest are shallow and located coastally and had no iron detected in 2021. All sites show no trend in iron.
Nitrate-N	11.3 g/m^3-N (short term)	Trend: No major change across the Aorere/West Coast Water Management Zone. All sites are below 10% of the MAV for nitrate concentration and show no trend.
pH	7.0 – 8.5 pH units	Trend: No major change across the Aorere/West Coast Water Management Zone. Most bores had pH between 6 and 8 with no major change in pH throughout the years.
Temperature	ºC	Trend: No major change across the Aorere/West Coast Water Management Zone. Generally the water temperature for all bores is between 13 – 17 degrees, with no apparent change in temperature throughout the years.

Trend analysis of groundwater quality per parameter in the Aorere/West Coast Water Management Zone. Historic data was plotted then fit with a linear trend line. Trends were identified when the gradient was large (either positive or negative), combined with a high r^2 value (coefficient of determination – the proportion of the variance in the dependent variable that is predictable from the independent variable. An r^2 of 1 means the data falls directly on the trend line, r^2 of 0 means utterly random scatter), and also a large difference of the 2021 sample result from the historic bore mean data.

Table 7: Conductivity data analysis over time for the Aorere/West Coast Water Management Zone.

Conductivity	2021 Result	Bore Mean	Gradient	r^2 Value	Trend
GW 5023	115.5	98.1	N/A	N/A	Unknown. 2 data points.
GW 5034	42.4	93.93333	N/A	N/A	Unknown. 3 data points.
GW 7031	847	343.5667	N/A	N/A	Unknown. 3 data points.
GW 23759	82	82.28	0.0017	0.0373	No significant trend

Table 8: E.coli data analysis over time for the Aorere/West Coast Water Management Zone.

E.coli	2021 Result	Bore Mean	Gradient	r^2 Value	Trend
GW 5023	2	2	N/A	N/A	Unknown. 2 data points.
GW 5034	4	52	N/A	N/A	Unknown. 3 data points.
GW 7031	19	559.5	N/A	N/A	Unknown. 3 data points.
GW 23759	N/A	N/A	N/A	N/A	Parameter not sampled

Table 9: Iron data analysis over time for the Aorere/West Coast Water Management Zone.

Iron	2021 Result	Bore Mean	Gradient	r^2 Value	Trend
GW 5023	0.23	0.115	N/A	N/A	Unknown. 2 data points.
GW 5034	< 0.02	1.225	-0.53	0.0871	No significant trend
GW 7031	< 0.02	0.62575	-0.2629	0.0823	No significant trend
GW 23759	0.02	0.0128	-0.0000006	0.0259	No significant trend

Table 10: Nitrate-N data analysis over time for the Aorere/West Coast Water Management Zone.

Nitrate-N	2021 Result	Bore Mean	Gradient	r^2 Value	Trend
GW 5023	0.3	0.415	N/A	N/A	Unknown. 2 data points.
GW 5034	0.133	1.1685	-1.1962	0.5825	No significant trend
GW 7031	0.052	0.267	0.2708	0.5551	No significant trend
GW 23759	0.86	1.1272	0.0002	0.0313	No significant trend

Table 11: pH data analysis over time for the Aorere/West Coast Water Management Zone.

pH	2021 Result	Bore Mean	Gradient	r^2 Value	Trend
GW 5023	6.36	6.435	N/A	N/A	Unknown. 2 data points.
GW 5034	7.45	7.45	N/A	N/A	Unknown. 2 data points.
GW 7031	7.16	7.53	N/A	N/A	Unknown. 2 data points.
GW 23759	5.9	6.172	0.00004	0.015	No significant trend

Table 12: Temperature data analysis over time for the Aorere/West Coast Water Management Zone.

Temperature	2021 Result	Bore Mean	Gradient	r^2 Value	Trend
GW 5023	16.6	16.55	N/A	N/A	Unknown. 2 data points.
GW 5034	17	15.43333	N/A	N/A	Unknown. 3 data points.
GW 7031	16.8	16.16667	N/A	N/A	Unknown. 3 data points.
GW 23759	14.5	14.22105	0.0007	0.2335	No significant trend

APPENDIX VII

Health significant, aesthetic and bacteriological parameters for the 2021 Aorere/West Coast surface water sites.

Table 13: National Policy Statement for Freshwater Management parameters for 2021 Aorere/West Coast surface water sites

Parameter	NPSFM (Attribute State)	Findings
Dissolved oxygen concentration	mg/L 7-day mean minimum A = ≥8 B = 7-8 C = 5-7 D = <5 Lowest 1-day minimum A = ≥7.5 B = 5-7.5 C = 4-5 D = <4	*Coastal*: Seven of the coastal river sites were above 10 mg/L (giving an attribute state of A). One coastal river site was 5.9 mg/L (attribute state B or C depending on statistic used). One coastal spring site was 4.19 mg/L (attribute state C or D depending on statistic used). *Inland*: All inland river sites were above 10 mg/L (giving an attribute state of A). Two inland springs were between 7.5-8 mg/L (attribute state A or B depending on statistic used). One inland spring was 6.13 mg/L (attribute state B or C depending on statistic used). One inland spring was 3.5 mg/L (attribute state D).
Dissolved reactive phosphorus	g/m^3 Single measurement A = <0.01 B = ≥0.01 C = n/a D = n/a	*Coastal*: All coastal rivers and springs were less than 0.01 g/m^3 (giving an attribute state of A). *Inland*: All inland rivers were less than 0.01 g/m^3 (giving an attribute state of A). One spring was also less than 0.01 g/m^3 (giving an attribute state of A). The rest of the inland springs were above 0.01 g/m^3 (giving an attribute state of B).
Escherichia coli	MPN/100mL Annual median and/or 95th percentile A = ≤260 B = 260-540 C = 540-1000	*Coastal*: Seven coastal rivers and the coastal spring were less than 260 MPN/100mL (giving an attribute state of A). One river was 365 MPN/100mL (attribute state B).

	D = >1000	*Inland*: All inland rivers and one spring were less than 260 MPN/100mL (giving an attribute state of A). One spring was 387 MPN/100mL (attribute state B). One spring was 548 MPN/100mL (attribute state C). One spring was 1,986 MPN/100mL (attribute state D).
Nitrate-N	g/m^3-N Annual median A = $\leq$1.0 B = 1.0-2.4 C = 2.4-6.9 D = >6.9 Annual 95th percentile A = $\leq$1.5 B = 1.5-3.5 C = 3.5-9.8 D = >9.8	*Coastal*: All coastal rivers and spring were less than 1.0 g/m^3-N (giving an attribute state of A regardless of statistic used). *Inland*: All inland rivers and one spring were less than 1.0 g/m^3-N (giving an attribute state of A regardless of statistic used). Two springs were 2.1 g/m^3-N (attribute state B regardless on statistic used). One spring was 2.7 g/m^3-N (attribute state B or C depending on statistic used).
pH	pH units Single measurement A = 6.5-8.5 B = 5-6.5 or 8.5-9 C = <5 or >9 D = n/a	*Coastal*: Seven coastal rivers and the coastal spring was between 6.5-8.5 (giving an attribute state of A). One river was 6.26 (attribute state B). *Inland*: All inland rivers and one spring were between 6.5-8.5 (giving an attribute state of A). The other inland springs were between 5-6.5 (attribute state B).
Temperature	^oC Midpoint of daily mean and daily maximum A = $\leq$18 B = 18-20 C = 20-24 D = >24	*Coastal*: All coastal rivers and spring were less than 18 ^oC (giving an attribute state of A). *Inland*: All inland rivers and springs were less than 18 ^oC (giving an attribute state of A).

Table 14: Health significant parameters for 2021 Aorere/West Coast surface water sites

Parameter	DWSNZ (MAV)	Findings
Fluoride	1.5 g/m^3	*Coastal*: Four sites (three rivers, one spring) were below 10% of MAV. The rest below the limit of detection. *Inland*: One site (river) was below 10% of MAV. The rest below the limit of detection.
Manganese	0.4 g/m^3	*Coastal*: All river sites were below 10% of MAV. The spring site was below limit of detection. *Inland*: All springs were below 10% of MAV. One river site was below limit of detection, the rest were below 10% of MAV.
Mercury	0.007 g/m^3	*Coastal*: All sites were below limit of detection. *Inland*: All sites were below limit of detection.
Nitrite-N	0.91 g/m^3-N (short term)	*Coastal*: All sites were below limit of detection. *Inland*: All springs were below 10% of MAV. All river sites were below limit of detection.
Nitrate-N	11.3 g/m^3-N (short term)	*Coastal*: All river and spring sites were below 10% of MAV. *Inland*: All rivers and one spring site were below 10% of the MAV. Three spring sites were above 10% MAV, but below 50% MAV.

Table 15: Bacteriological parameters for 2021 Aorere/West Coast surface water sites

Parameter	DWSNZ (MAV)	Findings
Total Coliforms		*Coastal*: Highest coastal site (river) had exceeded the limit of detection (>2,420 MPN/100mL). All river sites were above 100 MPN/100mL,

		with three river sites above 1,000 MPN/100mL. The coastal spring site was 1 MPN/100mL. *Inland*: All inland spring sites exceeded the limit of detection (>2,420 MPN/100mL). Two inland river sites were above 1,000 MPN/100mL. The rest of the inland river sites were above 100 MPN/100mL.
Escherichia coli	< 1 MPN/100mL	*Coastal*: Highest coastal site (river) was 365 MPN/100mL. Two coastal river sites were above 200 MPN/100mL. The rest of the coastal river sites were below 100 MPN/100mL. The coastal spring site was below limits of detection. *Inland*: The highest inland site (spring) was 1,986 MPN/100mL. The rest of the inland springs were above 200 MPN/100mL. The inland river sites were all below 100 MPN/100mL.